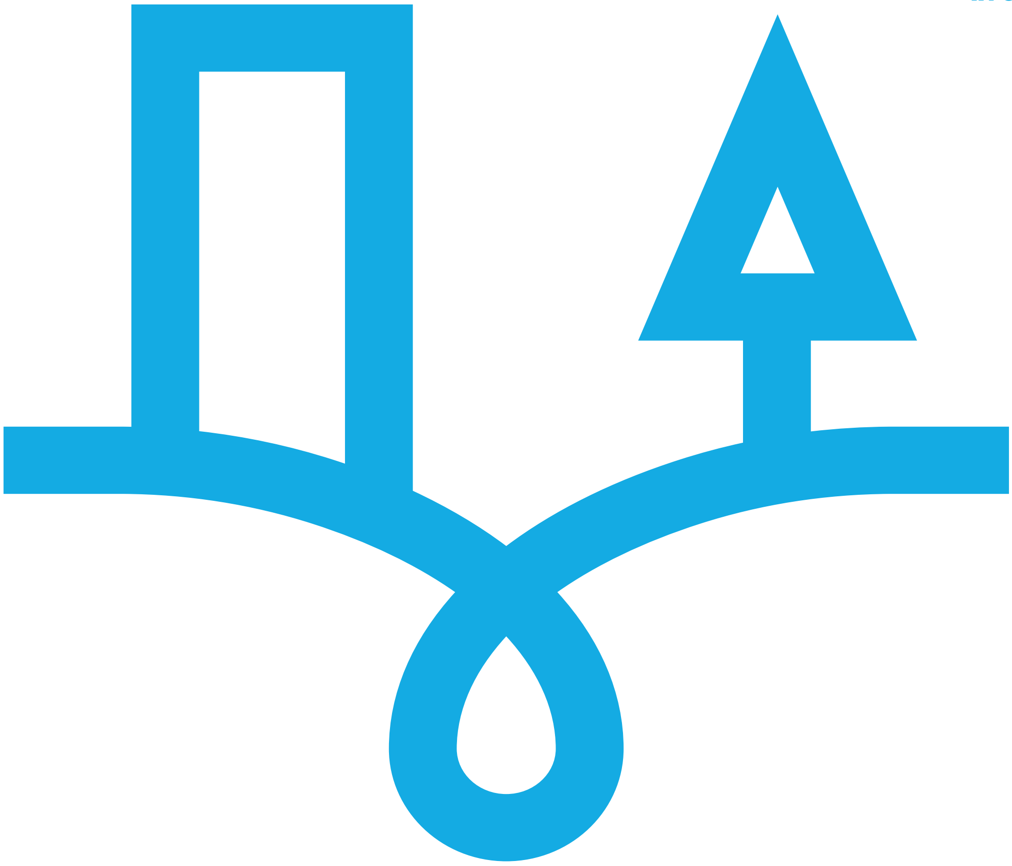
CIRCULAR
ECONOMY
IN CITIES



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URBAN BUILDINGS SYSTEM SUMMARY

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URBAN BUILDINGS SYSTEM

A thriving city needs to offer affordable, healthy living and working space. By 2025, 1 billion houses are needed worldwide, of which 75% will be residential and 25% will be commercial.[1] However, meeting this demand through current linear construction and housing practices will require an investment of around USD 9–11 trillion overall and have significant negative environmental impacts – such as the impacts from extraction that are felt locally as well as globally.[2]

DRIVERS FOR CHANGE

One-third of urban residents struggle to secure decent housing[3]

$650bn

By 2025, **1 billion** new homes are needed worldwide costing an estimated USD 650 billion per year, or **USD 9–11 trillion** overall[4]

49%

49% owner-occupied homes in the UK are ‘under-occupied’ (at least two bedrooms more than stated need)[5]

60%

60% of European office space is unused during working hours[6] and in India **15%** of office space is reported vacant[7]

9 out of 10 existing buildings in the EU will still be in use in 2050[8]

Construction materials and the building sector are responsible for **more than one-third** of global resource consumption[9]

Up to 40% of urban solid waste is construction and demolition waste[10]

21%

In the OECD, households on average spend around **21%** of their gross adjusted disposable income on keeping a roof over their heads[11]

Around **30%** of global energy consumption and energy-related CO_2 emissions are attributed to the use of buildings[12]

HOW CAN A CIRCULAR ECONOMY APPROACH ADDRESS THESE CHALLENGES?

Integrating circular economy principles into all the phases of a building's cycle can work to meet urban needs for built space, while staying within planetary boundaries.[13] Core urban benefits of a circular economy development path include the possibility to reduce the need for new construction, improve urban land use, reduce construction and operational costs, and increase resource-efficiency, while strengthening the local economy.

Now is the time to act. A building can be of use for over a century and more, which means how cities address their urban housing needs today will define urban development for decades to come. Innovations within the construction and housing sectors can, if applied with a circular economy approach, provide the solutions we need.

"The latest estimates for the potential from circular economy opportunities in the built environment add £3–5bn annually to GDP by 2036."[20]

London Waste and Recycling Board, Towards a circular economy – context and opportunities (2015)

SUMMARY

PHASE	EXAMPLES OF CIRCULAR ECONOMY OPPORTUNITY
p PLANNING	1. Planning compact cities – dense, mixed-use, and transit-oriented 2. Planning for local circular material flows
d DESIGNING	1. Designing for adaptable and flexible use 2. Using collaborative design processes 3. Integrating material choices into design 4. Taking inspiration from nature
m MAKING	1. Sourcing materials strategically 2. Building with resource-efficient construction techniques 3. Building 'buildings as material banks' (BAMB)
a ACCESSING	1. Accessing residential space through shared-use schemes 2. Accessing commercial space through shared-use schemes 3. Increasing the use of space through design features
o OPERATING AND MAINTAINING	1. Using smart technology to run buildings effectively 2. Using product-as-a-service models for building fit-outs 3. Adapting buildings for alternative uses 4. Refurbishing buildings to run them efficiently

PHASE	EXAMPLES OF BENEFITS	
PLANNING	**Strengthening local communities** Mixed-use neighbourhoods that encourage walking are most likely to be associated with positive social encounters and a strong sense of community. Surveys show that people in high-density, walkable communities are more likely to trust or socialise with their neighbours, volunteer or vote.[14]	COMMUNITY AND SOCIAL PROSPERITY
DESIGNING	**Reducing air pollution** Green façades can lead to a reduction in concentrations of particulate matter by 10–20% in the immediate surroundings.[15]	HEALTH AND ENVIRONMENT
MAKING	**Lowering unemployment** Integration of circular economy principles in the construction supply chain of 70,000 new homes in Amsterdam before 2040 can generate 700 additional jobs. The approximately 1% gain would be a significant contribution, resulting in a 10% drop in unemployment in the construction sector.[16]	JOBS, SKILLS, AND INNOVATION
ACCESSING	**Increasing utilisation** In London, peer-to-peer renting, better urban planning, office sharing, repurposed buildings, and multi-purposed buildings increases the value of new buildings and can double utilisation of 20% of London's buildings by 2036, saving over GBP 600 million annually.[17]	ECONOMIC PRODUCTIVITY
OPERATING AND MAINTAINING	**Reducing energy consumption through refurbishment** Through simple refurbishment solutions, it is possible to reduce energy consumption by 20–30% in existing buildings.[18] Deep refurbishment can cut building-related energy consumption in Europe up to 80%, saving the EU over 30% of its total energy use (equivalent of 4 billion barrels annually).[19]	RESOURCE USE

ENDNOTES

1 McKinsey, *Urban world: cities and the rise of the consuming class* (2012) p. 35

2 UN Habitat, *Urbanization and development: emerging futures world cities report* (2016) p. 47

3 McKinsey, *Tackling the world's affordable housing challenge* (October 2014)

4 UN Habitat, *Urbanization and development: emerging futures world cities report* (2016) p. 47

5 Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment, *Growth Within: a circular economy vision for a competitive Europe* (2015) p. 83

6 Ibid.

7 Ellen MacArthur Foundation, *Circular economy in India: rethinking growth for long-term prosperity* (2016) p. 34

8 Renovate Europe, *Multiple benefits of renovating*, renovate-europe.eu

9 OECD, *Working party on resource productivity and waste: a policy study on the sustainable use of construction materials* (2015) p. 4

10 World Bank, *What a waste: a global review of solid waste management* (2012) p. 16

11 OECD Better Life Index, *Housing*

12 UN Environment, *Global status report 2017: towards a zero-emission, efficient, and resilient buildings and construction sector* (2017) p. 14; International Resource Panel, *The weight of cities* (2018)

13 Stockholm Resilience Centre, *Planetary boundaries framework*

14 C. Montgomery, *Tackling the crisis of social disconnection*, Happy City (1 July 2017), Happy City, *Walkability*

15 Arup, *Cities alive: green Building Envelope* (2013) p. 13

16 Circle Economy, .Fabric, TNO, Gemeente Amsterdam, *Circular Amsterdam: a vision and action agenda for the city and metropolitan area* (2016) pp. 4, 40

17 London Waste and Recycling Board, *Towards a circular economy – context and opportunities* (2015) p. 22

18 Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment, *Growth Within: a circular economy vision for a competitive Europe* (2015) p. 85

19 European Parliament, *Boosting building renovation: what potential and value for Europe?* (2016) pp. 21, 51, Renovate Europe, *Multiple Benefits of Renovating*, renovate-europe.eu

20 London Waste and Recycling Board, *Towards a circular economy – context and opportunities* (2015) p. 22

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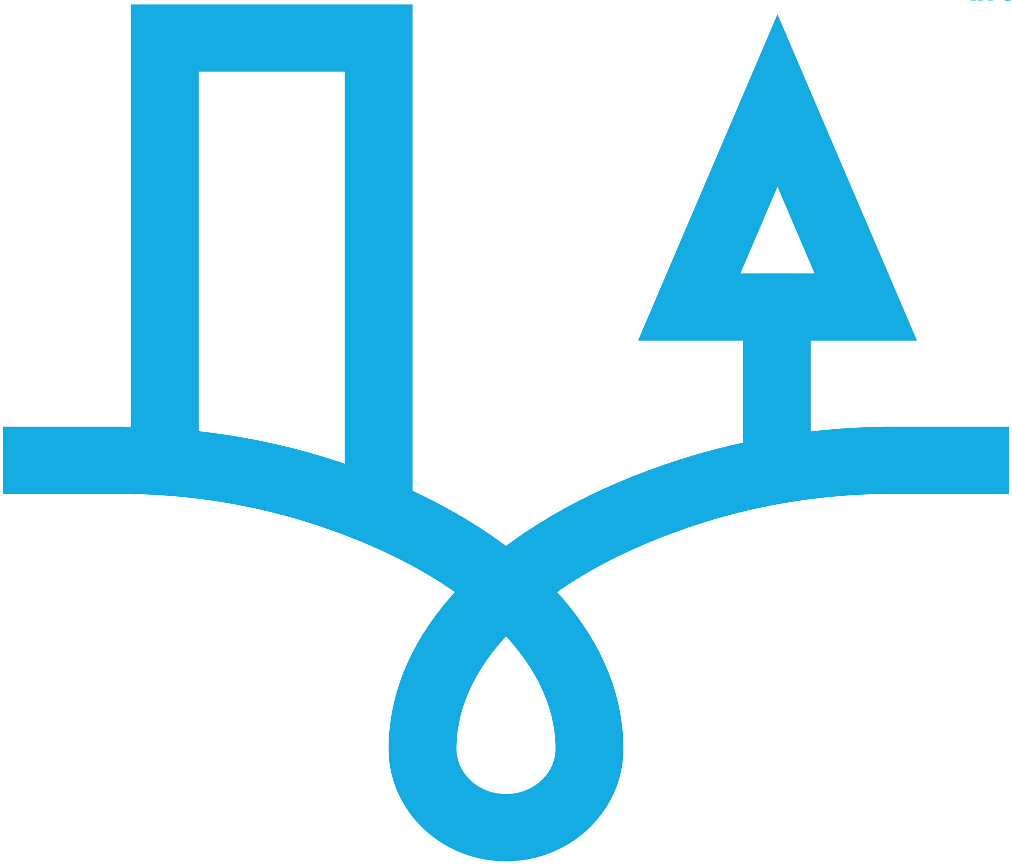

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PLANNING FOR COMPACT, CONNECTED CITIES

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How a city's buildings are planned and developed has a significant impact on urban living conditions and on resource consumption. The physical structure of a city is fundamental to how a city functions. Urban planning in a city includes making decisions on the placement of buildings, their use, and urban density. Planning for compact, connected cities can ensure that land is used effectively and support the looping of local material flows while at the same time increasing urban quality of life.

CASE FOR CHANGE

$650bn

By 2025, **1 billion** new homes are needed worldwide, costing an estimated **USD 650 billion** per year, or **USD 9–11 trillion** overall[1]

In 2010, as many as **980 million** urban households lacked decent housing[2]

Carbon emissions and energy consumption are closely connected to urban density and structure[3]

In 2018, **60%** of urban space was sparsely populated[4]

15% of urban land in the US is vacant[5]

Decisions about where buildings are placed will have implications for **one third** of a typical US municipality's budget[6]

"Spatial development has very strong 'lock-in' effects. As carbon emissions and energy consumption are closely connected to urban form, actions that influence land use and spatial development are among the most critical to achieving a low-carbon society."

European Environment Agency, Urban sustainability issues — what is a resource-efficient city? (2015)

EXAMPLES OF CIRCULAR ECONOMY OPPORTUNITIES

Planning compact cities – dense, mixed-use, and transit-oriented

Compact cities can avoid sprawling by allowing for higher densification around mass-transit lines. This increases urban connectivity and saves on resources and costs in several ways, including through reduced energy use due to shorter transport distances, more energy-efficient heating of buildings, and increased cost-efficiency of public infrastructure and services. Planning for mixed-use development (the co-location of commercial, residential, and recreational space) further reduces travel distances, distributes and evens out traffic flows, supports the shared use of buildings and parking space, and helps regenerate neighbourhoods.[7] Compact planning can apply as much to new urban developments as to regeneration or infill projects where disused, abandoned or vacant lots are reintegrated into the city.

Planning for local, circular material flows

The spatial planning of residential and/or industrial sites provides a key moment to lay the foundations for future circular material flows and resource self-sufficiency. By integrating circular economy principles early in the urban development process, planners can ensure that the physical structure of the city and its infrastructure are conducive to the effective reuse, collection, and redistribution of resources such as water, organics, industrial by-products, building elements, and household recyclables. See *Policy levers.*

RELEVANT CASE EXAMPLES

Compact city development in Curitiba

More than 30 years ago, the city of Curitiba started to grow using a compact city development strategy, which entailed mixed-use development and densification along five transport corridors served by a bus rapid transit (BRT) system. The development strategy has helped to improve the use of urban land, increase public transport use, and reduce the demand for private transport fuel. Today, Curitiba is one of Brazil's wealthiest cities, and the city has managed to maintain some of the lowest congestion and transport costs in Brazil (around 10% of income).[8]

Crowdsource-mapping of vacant space for community use in New York City

New York City has a large number of publicly owned vacant lots. These empty spaces fill with rubbish and blight communities they could otherwise enliven. A citizen-driven pilot project, 596 Acres, created an interactive crowdsourced map of vacant space, and assisted neighbourhood-led campaigns to turn inner-city land into community space, such as gardens, farms, and playgrounds that support social cohesion and effective land use. As of October 2016, over 7 acres of new community spaces have been created.[9]

Site-specific urban planning for material flows and resources re-capture

In London, circular economy principles were integrated into the preliminary draft local plan for the regeneration of the Old Oak and Park Royal districts.[10] The plan aims to create more than 25,500 new homes and 65,000 jobs in 640 hectares of residential and industrial area, while at the same time ensuring optimal local materials circulation to develop an "exemplary world class neighbourhood underpinned by new business models, as well as new cultures of collaboration, innovation and community engagement".[11] Key opportunities identified in the current planning phase are for buildings, fitouts, infrastructure, and spaces to be designed for reuse and disassembly from the outset, as well as resource-efficiency, sharing, and adaptability. By capturing local resources such as water, heat, organics, and solid waste for reuse and using underused space for farming, the draft plan aims to ensure the area's environmental and economic resilience.[12]

EXAMPLES OF WHAT URBAN POLICYMAKERS CAN DO

Setting out a clear **roadmap and strategy** for the urban building stock is key to informing and directing other policy levers. For example, setting a strategy for the **asset management** of urban land will have long-term consequences. **Urban planning**, such as spatial and land-use planning, is also frequently within the remit of city governments. Other policy instruments, such as **legislation and regulation** around land and property, can also influence urban spatial development.

To explore further see **Policy Levers**

EXAMPLES OF LINKS TO OTHER SYSTEMS AND PHASES

Mobility: Planning and Products: Planning The physical structure of a city's built space has a significant impact on the effectiveness of urban mobility and how well people can move around the city, and how well products, materials, and by-products can be moved around the city for reuse and recycling, highlighting the importance of thinking across systemic thinking.

EXAMPLES OF BENEFITS:

ECONOMIC PRODUCTIVITY

Reducing infrastructure costs

Compact urban development can save 38–50% on upfront costs for new construction of roads, sewers, water lines, and other infrastructure.[13]

Reducing development and operational costs

London, Ontario, estimates sprawling development patterns will cost an extra CAD 2.7 billion in capital expenditures plus CAD 1.7 billion in operating expenses compared to compact growth annually.[14]

Reducing the cost of urban services

Sprawl puts pressure on local public finances as it is more expensive to provide urban infrastructure in sprawling low-density areas.[15] By contrast, compact cities can save municipalities an average of 10% on police, ambulance, and fire service costs by reducing the distances service vehicles must drive.[16]

Reducing motorised travel needs

Mixed-use redevelopment of the Southern Industrial Area (SIA) in Sydney is estimated to generate commuter-related savings of USD122 million a year (which includes the time saved by commuters and the value of avoided externalities, such as vehicle emissions and road wear).[17]

JOBS, SKILLS, AND INNOVATION

Increasing access to work

Compact, transit-oriented development is important as people living near public transport services can work more days annually than those without such access. Public transport commuters report that they would earn less, or not be able to continue in current jobs, if public transport services were not available.[18]

HEALTH AND ENVIRONMENT

Decreasing emissions from compact growth

Barcelona and Atlanta have similar income levels and populations, however due to high urban density Barcelona's urban transport area is 26 times smaller and its CO_2 emissions are 10 times lower.[19]

COMMUNITY AND SOCIAL PROSPERITY

Strengthening local communities

Mixed-use neighbourhoods that encourage walking are most likely to be associated with positive social encounters and a strong sense of community. Surveys show that people in high-density, walkable communities are more likely to trust or socialise with their neighbours, volunteer or vote.[20]

RESOURCE USE

Putting vacant buildings into use

Up to 600 empty apartments in high-demand areas in Barcelona could be put into use to ease housing shortages following the city's new policy to demand repossessed bank-owned properties be put back into use if they have been vacant for more than two years.[21]

Reducing total land use in compact cities

Changes such as shifting land use patterns, taking advantage of inner-city vacant land and promoting compact urban growth, can reduce land use by as much as 75% compared with a sprawl scenario.[22]

Reducing energy use in compact cities

Energy consumption can be reduced by a factor of two or more by planning and designing liveable, functional, and socially mixed neighbourhoods that have a dense structure made up of small-scale urban blocks and compact street patterns.[23]

ENDNOTES

1 UN Habitat, *Urbanization and development: emerging futures world cities report* (2016) p. 47

2 Ibid.

3 European Environment Agency, *Urban sustainability issues — what is a resource-efficient city?* (2015) p. 48

4 OECD, *Rethinking urban sprawl: moving towards sustainable cities* (2018) p. 3

5 M. Pagano and A. Bowman, V*acant land in cities: an urban resource* (2000) p. 1

6 Smart Growth America, *Building better budgets* (2013) p. 1

7 UN Habitat, *Planning and design for sustainable urban mobility: global report on human settlements* (2013) pp. vii, 39, 91–93

8 Ibid., p. 98; C40 Cities, *Good practice guide: Bus Rapid Transit* (2016) p. 15; , J. Goodman *et al.*, *Curitiba's bus system is model for rapid transit*, Race Poverty and the Environment (2005) pp. 75–76

9 596 Acres, *Impact*, One Dollar Lots; onedollarlots.org

10 Old Oak and Park Royal Development Corporation, *Local plan second revised draft for regulation 19 (2) consultation* (2018) pp. 20, 31, 124, 154

11 ARUP, OPDC, and LWARB, *Circular and sharing economy scoping study for Old Oak and Park Royal* (2017)

12 Old Oak and Park Royal Development Corporation, *Local plan second revised draft for regulation 19 (2) Consultation* (2018) p. 20, 31, 124, 154

13 Smart Growth America, *Building better budgets* (2013) p. ii

14 City of London, *Ontario, Building a mixed-use, compact city* (2013) p. 40

15 OECD, *Rethinking urban sprawl* (2018)

16 Smart Growth America, *Building better budgets* (2013) p. iii

17 Deloitte, *The benefits of mixed use in the Southern Industrial Area* (2015) p. ii

18 UN Habitat, *Planning and design for sustainable urban mobility: global report on human settlements* (2013) p. 24–25

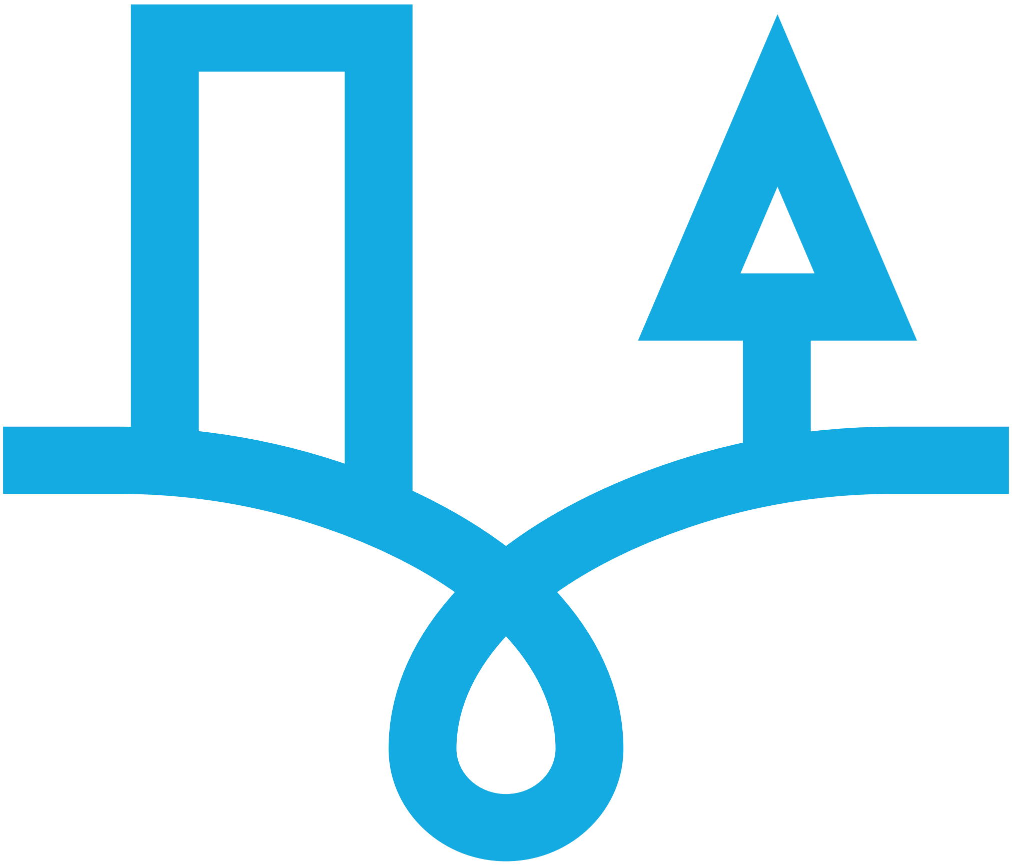
19 New Climate Economy, *Better growth, better climate: the new climate economy Report* (2014) p. 61

20 C. Montgomery, *Tackling the crisis of social disconnection*, Happy City (1 July 2017) , Happy City, *Walkability*

21 F. O'Sullivan, *Barcelona forces banks to turn repossessed homes into affordable housing*, CityLab (17 April 2018)

22 Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment, *Growth Within: a circular economy vision for a competitive Europe* (2015) p. 86

23 International Resource Panel, *The weight of cities* (2018) p. 79



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DESIGNING BUILDINGS FOR ADAPTABLE USE, DURABILITY, AND POSITIVE IMPACT

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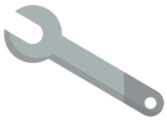
How buildings are designed is key to how they are used, the impact they have on their surroundings, and how long they are fit for purpose for. Design can either improve or impede building performance, longevity, use, and after-use management. Incorporating circular economy principles into the design of buildings is therefore an important action to improve the time they are fit for purpose, as well as optimising construction and disassembly.

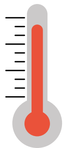
CASE FOR CHANGE



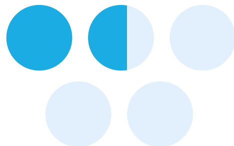
Only **20–30%** of construction and demolition waste (CDW) is recycled or reused, which is often due to poor design and lack of information on building contents[1]

80%

More than **80%** of the total energy consumption in a building's life is consumed during its use[2]



US cities may be **1–3°C** warmer in the daytime and up to **12°C** warmer in the evening than surrounding areas due to the heat-island effect[3]



33% of people over 60 in the UK would like a smaller residence, but only **10%** actually downsize[4]

EXAMPLES OF CIRCULAR ECONOMY OPPORTUNITIES

Designing for adaptable and flexible use

New concepts and techniques, such as modular units and moveable interior walls, are bringing greater flexibility and resource-efficiency into residential and commercial buildings. These methods support the efficient and effective use of a building during its lifetime, such as repurposing a commercial building into housing, using modularity to downsize a home or an office, or supporting sharing and mixed functionality.[5] Flexible design also supports incremental and participatory housing; to begin with, only the essential parts of the building are completed, allowing the residents to expand and adapt the building as they need and can afford. This also opens up a way for low-income groups to access better-quality housing while contributing to building longevity.[6]

Using collaborative design processes

Using collaborative, multi-stakeholder processes supported by Building Information Modelling (BIM)[7] in the design phase, allows designers to coordinate with other stakeholders (clients, engineers, developers, deconstruction companies). BIM platforms can bring together the entire supply chain, and enable the end-customer to know what is in the building, and what the building and its components have been used for. This transparency facilitates reuse and recycling of building components and materials. Open-source design platforms, such as WikiHouse, Paperhouses, and Abari, allow architects to share blueprints with end-users so that they can customise and construct buildings to their own needs. These blueprints inherently support adaptable and modular design. Open-source solutions can accelerate design innovation, as the platforms learn from their users, and offer another way to scale the uptake of best-practice circular economy building approaches.[8]

Integrating material choices into design

Building materials used today can be unsuitable for high-value reuse if they contain toxic or harmful elements. Selecting safe and healthy materials to be used in buildings can result in healthier living and working environments for residents, as well as encourage the looping of materials at the end of their use. Adapting a building's design to incorporate locally available materials could also then actively support a local economy that sources, uses, and reuses materials locally. (See *City Case Study: Venlo*)

Taking design inspiration from nature

Nature-inspired design can create effective building solutions. Using a building's exterior for energy production (for example by integrating solar panels in roofs, windows or façades) is widely applied and the technology continues to develop. Low-tech solutions, such as bioclimatic and passive design, make use of natural conditions to cool, heat, light, and ventilate buildings. These increase a building's performance, and minimise energy consumption.[9] Biophilic design, i.e. greening of building exteriors, façades and roofs, reduces air pollution, noise, flooding and the urban heat-island effect.

RELEVANT CASE EXAMPLES

Modular and flexible meeting rooms

A modular meeting room unit, called Jack, has been developed to meet Google's rapidly changing needs for meeting spaces. The unit can easily be assembled, reassembled, and reconfigured in a variety of ways to create differently sized, fully or partially enclosed spaces in Google's open-plan London office, which improves the work environment, use of the building, and increases productivity.[10]

Incremental social housing

The Iquique project in Chile is an incremental and participatory housing concept, developed by the company Elemental. With a budget of USD 7,500 per home (including land), buildings are designed for low-income households but with middle-class needs in mind. This ensures that the building's shell will be useful for longer and limits the need for reconstruction. Initially, only half of the building is constructed, including three floors with the essential elements such as a kitchen, bedroom, roof, and sanitary installations. This makes the house fully habitable, but with the anticipation of additional rooms being added as and when residents can afford the expansion.[11]

Low-energy building with flexible interior

White Collar Factory is a 16-storey building in London designed to reduce occupational carbon emissions by 25% and offer a 10–33% annual reduction in operational energy costs. It contains commercial, residential and public spaces, and has been designed using adaptable floor plates and internal fittings to allow for easy subdivision, interactivity and flexibility over time, which facilitate the prolonging of the building's lifespan. Integrated smart services including concrete core cooling, passive systems that maximise natural daylighting and ventilation, and power and data systems in raised access floors also help with repairs, maintenance, and longevity.[12]

Using the local climate and ancient design

Pearl Academy of Fashion in Jaipur mixes modern architecture with local ancient Rajasthani building technology to deal with a hot desert climate without artificial cooling. A 1,500-year-old cooling system (a pool of water in the base of the building) creates a comfortable microclimate that keeps the building 20 degrees Celsius cooler inside than the outdoor temperature. Other elements, such as latticed clay screens, absorb heat while decorating and enhancing cultural aesthetics.[13]

Singapore aims to be the greenest city in the world

Since the early 1960s, Singapore has had a strong ambition to green itself in order to become a highly liveable and competitive city. Sky-rise greenery has increasingly become an essential component of the city's development plan, in part due to the limited amount of land. The city's 72 hectares of rooftop gardens and green walls are set to triple by 2030. These, combined with 4,172 hectare of green space (parks and park connectors), reduce the city's heat-island effect, improve air quality, reduce noise, help absorb stormwater, and increase urban biodiversity.[14]

EXAMPLES OF WHAT URBAN POLICYMAKERS CAN DO

Through **convening** and consulting with industry stakeholders, incorporating circular economy criteria in **public procurement** tenders, and via **asset management**, city governments can incentivise circular economy practices in the built environment. **Capacity building** and training for professionals (such as designers, procurers or suppliers, and manufacturers) can also help change commercial practices. **Regulatory** specifications on building standards and materials can level the playing field in the market.

To explore further see **Policy Levers**

EXAMPLES OF LINKS TO OTHER SYSTEMS AND PHASES

Buildings: Making The design and construction of buildings are strongly linked and overlap. In a circular economy, decisions made at the design phase will work to support appropriate material sourcing and new construction methods during construction.

Buildings: Operating and Maintaining The design of buildings will also have a significant impact on the operational efficiency of the buildings and how easy they are to maintain or adapt.

EXAMPLES OF BENEFITS:

ECONOMIC PRODUCTIVITY

Reducing operation and maintenance costs

Implementation of circular economy design opportunities in Chinese cities, such as green and smart buildings, would reduce operation and maintenance costs by 10% in 2030 and 28% in 2040, compared with the current development path.[15]

Increasing workforce performance

Designing for better indoor air quality (low concentrations of CO_2 and pollutants, and high ventilation rates) in offices can lead to improvements in workforce performance of up to 8%.[16]

Increasing the value of buildings

Building owners report that green buildings – whether new or renovated – command a 7% increase in asset value over traditional buildings.[17]

HEALTH AND ENVIRONMENT

Reducing the need for air conditioning and heating

Trees in urban areas can cool the air by between 2 and 8 degrees Celsius, reduce air conditioning needs by 30%, and save energy used for heating by 20–50%.[18]

Reducing air pollution

Green façades can lead to a reduction in concentrations of particulate matter by 10–20% in the immediate surroundings.[19]

Reducing noise

Green façades can reduce sound levels from emergent and traffic noise sources by up to 10 dB(A).[20]

Supporting better health

Spending time near trees improves physical and mental health, while decreasing blood pressure and stress.[21]

Improving cognitive ability

People working in green, well-ventilated offices record a 101% increase in their cognitive scores (brain function).[22] Employees in offices with windows slept an average of 46 minutes more per night.[23]

COMMUNITY AND SOCIAL PROSPERITY

Improving living conditions

Green rooftops can facilitate social and recreational activities or be used for urban agriculture, which brings a broad range of societal benefits such as improved neighbourhood relations, worker creativity and productivity, or supporting learning and food production to increase self-sufficiency.[24]

RESOURCE USE

Reducing resource consumption and prolonging the building's lifespan

Modular design typically reuses 80% of the components in a building's exterior, coupling modularity with durability.[25]

Reducing material costs

Locally appropriate materials can be more affordable. In China, the cost of a bamboo façade could be 60% lower than that of a concrete one and can be built in a modular fashion, strongly supporting adaptable use.[26]

Reducing embodied energy

A bio-composite building façade panel could reduce the embodied energy in façade systems by up to 50% compared to conventional construction.[27]

Increasing resource-efficiency

Engineered clay can offer an alternative to concrete, and uses up to 15% less material, requires less energy to produce, and can be recycled after use.[28]

Reducing energy consumption

Insulated walls and efficient glazing can reduce energy consumption twofold or more.[29] Compared to traditional houses, buildings built to passive house standards save 80% of heating energy and 50% of energy for cooling and dehumidification.[30]

ENDNOTES

1 Ellen MacArthur Foundation, *Towards the circular economy* (2013) p. 16; M. Honicet *et al.*, *Data- and stakeholder-management framework for the implementation of BIM-based material passports*, Journal of Building Engineering (2019)

2 Ellen MacArthur Foundation, *Circular economy in India: rethinking growth for long-term prosperity* (2016) p. 30

3 Arup, *Cities alive: green building envelope* (2013) p. 24

4 Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment, *Growth Within: a circular economy vision for a competitive Europe* (2015) p. 83

5 Ibid., p. 86; K. Sailer/Google, *Project Jack – Google's answer to the problem of flexible spaces* (2016)

6 Hatje Cantz, *Social Housing Rethought* (2016)

7 BIM are digital files that can be extracted, exchanged or co-created to support decision-making regarding a building. Current BIM software is used by individuals, businesses, and government agencies who plan, design, construct, operate, and maintain diverse physical infrastructures and buildings. M. Honicet el., *Data- and stakeholder-management framework for the implementation of BIM-based material passports*, Journal of Building Engineering (2019)

8 Abari, *Open-source,* Abari.earth; Wikihouse, *About,* wikihouse.cc; Paperhouses, *About*, paperhouses.co

9 J. Knight, *Arup Thoughts: Don't ignore passive design*, Control Engineering (6 November 2015)

10 Sailer/Google, *Project Jack – Google's answer to the problem of flexible spaces* (2016)

11 Hatje Cantz, *Social housing rethought* (2016); R. Moore, *Alejandro Aravena: the shape of things to come*, the Guardian (10 April 2016)

12 Arup, *The Circular economy in the built environment* (2017) p. 27

13 N. Glass and G. Webster, *Ancient 'air-conditioning' cools building sustainably*, CNN (8 March 2012)

14 Government of Singapore, *Sustainable Singapore Blueprint* (2015) pp. 2, 4, 26; Arup, *Green building envelopes for lower city temperatures*

15 Ellen MacArthur Foundation, *The circular economy opportunity for urban and industrial innovation in China* (2018) p. 53

16 World Green Building Council, *About green buildings*, worldgbc.org

17 Dodge Data and Analytics, *World green building trends 2016: Europe* (2016) p. 1

18 Food and Agricultural Organisation, *Video: benefits of urban trees* (2016)

19 Arup, *Cities alive: green building envelope* (2013) p. 13

20 Ibid., p. 15

21 FAO, *Video: benefits of urban trees* (2016)

22 J. Allen *et al.*, *The impact of green buildings on cognitive function,* Harvard University (2015)

23 M. Boubekri *et al.*, *Impact of windows and daylight exposure on overall health and sleep quality of office workers: a case-control pilot study,* Journal of Clinical Sleep Medicine (2014)

24 Arup, *Cities alive: green building envelope* (2013) p. 37

25 Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment, *Growth Within: a circular economy vision for a competitive Europe* (2015) p. 86

26 Ellen MacArthur Foundation, *The circular economy opportunity for urban and industrial innovation in China* (2018) p. 47

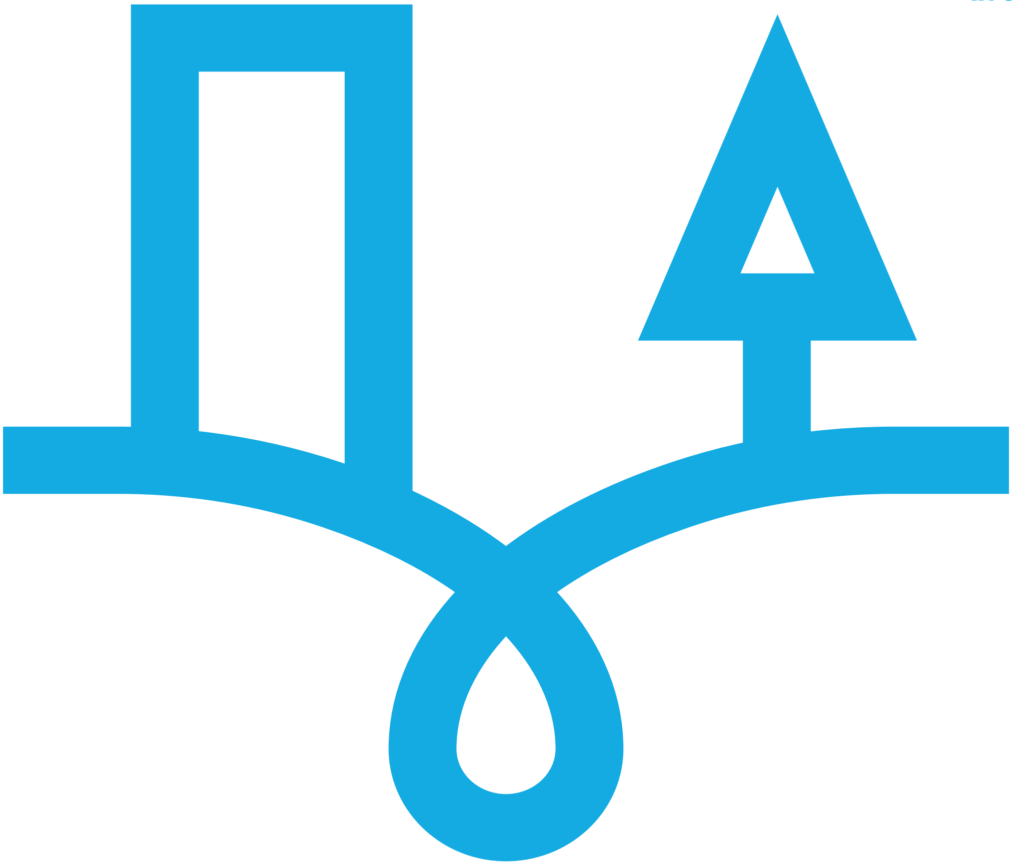
27 Ibid.

28 Ellen MacArthur Foundation, *Circular economy in India: rethinking growth for long-term prosperity* (2016) p. 37

29 International Resource Panel, *The weight of cities* (2018) p. 80

30 Ellen MacArthur Foundation, *The circular economy opportunity for urban and industrial innovation in China* (2018) p. 49

CIRCULAR
ECONOMY
IN CITIES



MAKING BUILDINGS WITH NEW TECHNIQUES THAT ELIMINATE WASTE AND SUPPORT MATERIAL CYCLES

ELLEN
MACARTHUR
FOUNDATION

ARUP

The construction and demolition of buildings accounts for around one-third of global material consumption and waste generation. This can be countered by implementing new construction and manufacturing techniques that are in line with circular economy principles.

CASE FOR CHANGE

Construction materials and the building sector are responsible for more than **one-third** of global resource consumption[1]

11% of global energy related CO_2 emissions can be attributed to the construction industry[2]

Up to 40% of urban solid waste is construction and demolition waste (CDW)[3]

54%

54% of construction and demolition waste in Europe is landfilled[4]

EXAMPLES OF CIRCULAR ECONOMY OPPORTUNITIES

Sourcing materials strategically

Selecting construction materials that can be sourced locally (including by-products), and kept in use continuously, can reduce virgin material demand. Materials made available during deconstruction could then be reused. Selecting renewable materials where appropriate, can furthermore reduce dependence on finite resources.

Building with resource-efficient construction techniques

New industrial construction techniques are gaining traction due to their many benefits, including cost-efficiency and reduced waste generation. Prefabricated building elements (such as a wall or sections of a wall) can easily be assembled on-site, significantly reducing construction time.
3D printing (also known as additive manufacturing) of building units on- or off-site, from components to entire buildings, can minimise waste generation and resource consumption.[5] This is because 3D printing eliminates off-cuts and can create shapes that use less material and that cannot be made using conventional techniques. For example, in China industrial construction techniques are being mainstreamed in accordance with a governmental target for 30% of new buildings in China to be prefabricated by 2026.[6]

Developing 'buildings as material banks' (BAMB)

Technology such as building information modelling (BIM) and similar digital building mapping technology can help turn buildings into 'banks of material'. With such building material maps, owners will have information on what materials and components are in the building, where they are sourced from, and guidance on their potential future use. This makes reusing building components and recycling materials significantly easier.[7]

RELEVANT CASE EXAMPLES

Industrial construction without waste

The Broad Group, a Chinese contractor specialising in industrial construction, has increased efficiency in production, installation, and logistics 6–10 times, with almost zero material waste and 40% lower total cost of construction. The Broad Group has demonstrated impressive time savings by constructing a 57-storey building in just 19 days.[8]

Building with locally salvaged materials

Villa Welpeloo is a Dutch house designed by Superuse that highlights the massive potential of unused or 'misplaced' resources. Aided by Google Earth, Superuse selected a construction area for a new building based on the area's proximity to industrial salvaged materials. This meant that they were able to construct the final building with 60% locally recovered material. The agency now uses this strategy on 90% of its projects and has created an online marketplace, Harvest.org, for upcyclers.[9]

Buildings as material banks

Arup's circular building pilot project harnessed technology to maximise the utilisation of components and materials. Arup designed the building for disassembly, using non-harmful and prefabricated components that could easily be taken apart. Arup applied BIM to enable the building to function as a material bank. The 3D BIM model for the building ensured transparency about the building's material composition. Using digital technology, all parts of the building, from window frames to individual fittings, were tagged with a unique QR code containing the information needed for reuse. This improved access to information that helped multiple stakeholders collaborate more efficiently on building design, construction, and operation. This information also enabled Arup to contract with suppliers to take back materials after their use.[10]

EXAMPLES OF WHAT URBAN POLICYMAKERS CAN DO

City governments can incentivise the use of new construction techniques and smarter material choices by specifying these in **public procurement** tenders for construction projects. Through **fiscal measures**, such as landfill taxes, and **regulation** on material management, city governments can encourage resource-efficient construction and de-construction practices. While industrial construction is less labour intensive than traditional construction practices, deconstruction (including reuse and recycling) is more labour intensive and entails higher skill-level requirements than demolition and landfilling. To support this, developing **capacity-building** programmes for construction workers can be an important way of ensuring the demand for expertise and skills can be met and new job opportunities can be opened up. The creation of material passports for public buildings will better support the **asset management** of these buildings, as cities will have much clearer information about the building materials they own and their potential for reuse.

To explore further see **Policy Levers**

EXAMPLES OF LINKS TO OTHER SYSTEMS AND PHASES

Buildings: Designing The way new buildings are constructed, and later disassembled, is highly dependent on building design. For example, whether the design supports industrial construction techniques and appropriate material sourcing.

Mobility: Planning Industrial construction techniques can reduce the amount of heavy freight needed in and out of the city. This will have positive impact on urban mobility, especially in fast-expanding cities.

EXAMPLES OF BENEFITS

ECONOMIC PRODUCTIVITY

Decreasing construction time and increasing resource-efficiency

Industrial construction techniques, such as 3D printing and off-site prefabrication, can reduce construction time by 50–70%.[11]

Increasing economic productivity

By integrating circular economy principles in the building construction chain in Amsterdam for 70,000 new homes by 2040, the city can achieve a 3% productivity increase worth EUR 85 million per year.[12]

JOBS, SKILLS, AND INNOVATION

Creating jobs and skills opportunities

Studies in the US and UK have found that deconstruction requires significantly more labour than demolition – one 'landfill job' can be replaced by 10 'resource recovery' jobs. Deconstruction also paves the way for employment and training opportunities for relatively unskilled and low-skilled workers. These workers can receive on-the-job training and the basic skills needed for deconstruction can be easily learned and transferred to the construction trades.[13]

Lowering unemployment

Integration of circular economy principles in the construction supply chain of 70,000 new homes in Amsterdam before 2040 can generate 700 additional jobs. The approximately 1% gain would be a significant contribution, resulting in a 10% drop in unemployment in the construction sector.[14]

RESOURCE USE

Reducing material consumption

Adopting advanced construction technologies as well as reusing and recycling construction and demolition waste could reduce virgin material consumption in China's urban built environment by 18% in 2030 and by 71% in 2040.[15]

Saving materials and increasing self-sufficiency

Improving the reuse of materials in the construction of 70,000 new apartments in Amsterdam before 2040 can lead to a saving of 500,000 tonnes of materials required. Set against the current annual import of 1.5 million tonnes of biomass for the entire metropolitan region, this is significant.[16]

Increasing resource-efficiency

A circular economy development path for India could, by 2050, reduce resource use in the construction of new buildings, with 37% less virgin, non-renewable materials needed, 24% less water consumed, and 18% less inner-city land used compared with the current development scenario.[17]

Reducing material costs

Industrial construction uses less material and can generate 50% in material cost savings.[18]

Reducing waste with industrial construction techniques

Off-site industrial construction greatly reduces waste generation and all off-cuts can be fully recycled in the factory.[19]

Reducing waste to landfill

Scaling up reuse and recycling in Chinese cities would see 32 billion tonnes of urban construction and demolition waste recycled by 2040. Due to waste reduction, the landfill volume could be cut by 81% in 2040 when compared with the current development path.[20]

HEALTH AND ENVIRONMENT

Reducing air pollution

Use of industrial construction techniques could decrease dust pollution (PM2.5 and PM10 particulate emissions) from construction in Chinese cities by 11% in 2030 and by 61% in 2040.[21]

Reducing CO^2 emissions from processing

Processing of recycled aggregates can generate 40–70% less CO^2 emissions than the processing of virgin aggregates.[22]

Reducing CO^2 emissions from construction

Integration of circular economy principles in the construction of 70,000 new homes in Amsterdam before 2040 can reduce CO^2 emissions by 500,000 tonnes per year, equivalent to 2.5% of the city's annual CO^2 emissions.[23]

COMMUNITY AND SOCIAL PROSPERITY

Reducing disruption and noise

Industrial construction entails fewer site deliveries and reduces site traffic by up to 70%, compared to more traditional ways of building – minimising noise, dust, and overall disruptions in urban areas.[24]

ENDNOTES

1 OECD, *Working party on resource productivity and waste: a policy study on the sustainable use of construction materials* (2015) p. 4

2 UN Environment, *Global status report 2017: towards a zero-emission, efficient, and resilient buildings and construction sector* (2017) p. 14

3 World Bank, *What a waste: a global review of solid waste management* (2012) p. 16

4 Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment, *Growth Within: a circular economy vision for a competitive Europe* (2015) p. 20

5 Arup, *Additive manufacturing: design method for critical structural steel elements*, arup.com

6 Ellen MacArthur Foundation, *The circular economy opportunity for urban and industrial innovation in China* (2018) p. 47

7 Ellen MacArthur Foundation, *Circular economy in India: rethinking growth for long-term prosperity* (2016) p. 36; BAMB Buildings as Material Banks

8 Ellen MacArthur Foundation, *Circular economy in India: rethinking growth for long-term prosperity* (2016) p. 35

9 Ellen MacArthur Foundation, *Superuse Studios: Finding and utilising 'waste' materials for construction purposes*

10 Ellen MacArthur Foundation, *Circular economy in India: rethinking growth for long-term prosperity* (2016) p. 36

11 Ellen MacArthur Foundation, *A circular economy in Brazil: case study appendix* (2017) p. 9; Whirlwind Steel, *Impacts of 3D printing on the construction industry* (30 March 2016)

12 Circle Economy, .Fabric, TNO, Gemeente Amsterdam, *Circular Amsterdam A vision and action agenda for the city and metropolitan area* (2016) pp. 4, 40

13 OVAM, *Employment impact of the transition to a circular economy: literature study* (2018) p. 22

14 Circle Economy, Fabric, TNO, Gemeente Amsterdam, *Circular Amsterdam: a vision and action agenda for the city and metropolitan area* (2016) pp. 4, 40

15 Ellen MacArthur Foundation, *The circular economy opportunity for urban and industrial innovation in China* (2018) p. 54

16 Circle Economy, .Fabric, TNO, Gemeente Amsterdam, *Circular Amsterdam: a vision and action agenda for the city and metropolitan area* (2016) p. 40

17 Ellen MacArthur Foundation, *Circular economy in India: rethinking growth for long-term prosperity* (2016) p. 38

18 Ellen MacArthur Foundation, *A circular economy in Brazil: case study appendix* (2017) p. 9; Whirlwind Steel, *Impacts of 3D printing on the construction industry* (30 March 2016)

19 R. Lawson and R. Ogden, *Sustainability and process benefits of modular construction*, Proceedings: TG57 – Special Track. 18th CIB World Building Congress (2010) p. 50

20 Ellen MacArthur Foundation, *The circular economy opportunity for urban and industrial innovation in China* (2018) p. 53

21 Ellen MacArthur Foundation, *The circular economy opportunity for urban & industrial innovation in China* (2018) p. 54

22 Ellen MacArthur Foundation, *Circular economy in India: rethinking growth for long-term prosperity* (2016) p. 37; Lendager Group, *The resource rows,* Lendager.com

23 Circle Economy, .Fabric, TNO, Gemeente Amsterdam, *Circular Amsterdam: a vision and action agenda for the city and metropolitan area* (2016) p. 4, 40

24 R. Lawson and R. Ogden, *Sustainability and process benefits of modular construction*, Proceedings: TG57 – Special Track. 18th CIB World Building Congress (2010) p. 50

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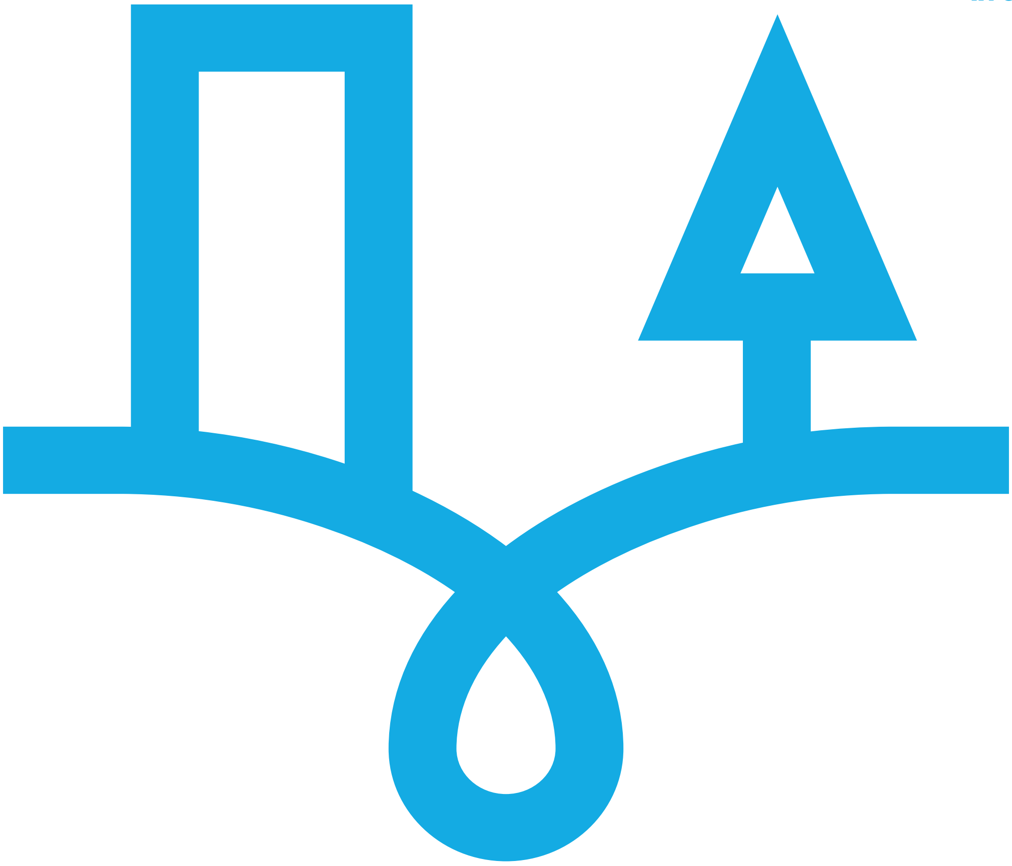

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ACCESSING AND USING RESIDENTIAL AND COMMERCIAL SPACE DIFFERENTLY

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FOUNDATION

ARUP

Buildings in cities are often underused, but this can be countered through shared use, new business models, and reconfigurable building designs. New sharing-schemes and business models for residential and commercial buildings can have numerous benefits, including lowering the financial barrier of accessing built space. Aided by digital technology, these use models are gaining traction through a broad range of different sharing schemes such as home sharing, co-living and co-working offices. Design features can also enable greater use of space, such as moving walls which enable users to reconfigure spaces as needs change, and thereby also improving building use.

CASE FOR CHANGE

Globally, one-third of urban dwellers struggle financially to secure decent housing[1]

In the OECD, households on average spend around **21%** of their gross adjusted disposable income on keeping a roof over their heads[2]

60%

60% of European office space is unused during working hours[3] and in India **15%** of office space is reported vacant[4]

49%

49% owner-occupied homes in the UK are 'under-occupied' (at least two bedrooms more than stated need)[5]

20% of retail space in New York City is vacant and fit for other commercial purposes[6]

EXAMPLES OF CIRCULAR ECONOMY OPPORTUNITIES

Accessing residential space through shared-use schemes

Temporary home sharing with visitors and tourists through online platforms has increased the use of spare rooms. For example, Airbnb is now considered one of the world's biggest 'hotel chains' and cities are working with such platforms to enable the benefits, while also mitigating unintended consequences, such as impacts on long-term rental markets and housing costs.[7] (See *City Case Study: Amsterdam*) Home-sharing models are also beginning to support more vulnerable groups in society. For example, intergenerational home sharing for the young and elderly is solving issues of loneliness and affordability.[8]

Accessing commercial space through shared-use schemes

Businesses are increasingly making use of shared offices and co-working spaces. Common examples of co-working spaces, include WeWork, who have 456 offices across seven cities, serving organisations from start-ups to corporates such as Microsoft and IBM.[9] In addition, organisations with surplus space – including desks, rooms, storage, and retail space – can engage with similar shared-use models to increase utilisation and create additional revenue while supporting other organisations and individuals who are in need of affordable space. Those with free space at home during the day can also offer their homes as office space, creating additional co-working spaces and communities for micro-businesses and independent professionals.[10]

Increasing the use of space through design features

Moveable interior walls are a designed-in feature of a building that can enable additional uses of a space. For example, these walls can enable a space to be reconfigured for the needs of different users at different times of day, or can enable a user, from organisations to individuals, to reconfigure their work or home space as their own requirements change, without the need for additional building and materials.

RELEVANT CASE EXAMPLES

Municipal office space used for skills training and development

Like most organisations, city governments have vacant or underutilised office space, which can be used to benefit wider city priorities. In Amsterdam, the municipality piloted a project in which they made meeting rooms available to organisations running coding lessons for refugees on weekends, when these meeting rooms otherwise stood empty. (See *City Case Study: Amsterdam*) In London, a government department worked with 3Space to enable the temporary use of surplus government buildings for start-ups and non-profits.[11]

Intergenerational sharing for societal benefits

Home Share Int. specialises in facilitating intergenerational home sharing, providing a solution to the needs of two groups of people – those in need of affordable housing (often younger people), and those in need of support to live independently at home (usually older people). The programme has also brought wider benefits such as intergenerational and cultural understanding, and reduced loneliness.[12]

Using empty restaurants as office space during the day

Restaurants that are closed during the daytime have valuable, but underutilised space. Such space can be used as a co-working space benefiting both restaurants (through extra revenue) and people in the need of office and meeting space (with cheaper rent or improved facilities). In San Francisco and New York City, the start-up Spacious provides an intermediary platform that connects restaurants and customers, and facilitates payment through a range of subscription models. Real-time tracking helps users select spaces that are less busy, avoiding overcrowding and helping less-known places to attract customers. In New York, more than 2,000 restaurants are closed during the day.[13]

Adaptable, multi-purpose spaces for multiple uses

Moveable interior walls and other features in offices can bring multiple benefits. Circl Pavilion at ABN AMRO offices in Amsterdam has multiple adaptable design features, such as walls and even floors, that enable a variety of spatial configurations to support the needs of employees and additional users. The offices can be configured for everything from day-care in the morning to dance events in the evening. The changeable space can also help to reduce energy needs.[14]

EXAMPLES OF WHAT URBAN POLICYMAKERS CAN DO

Through **asset management**, city governments can ensure increased utilisation of publicly owned buildings by making them available for use through sharing schemes. Through **convening and partnering** with residents and platform providers, and through **regulation**, urban policymakers can also support home and office sharing in a manner that preserves the benefits while mitigating unintended negative consequences.

To explore further see **Policy Levers**

EXAMPLES OF LINKS TO OTHER SYSTEMS AND PHASES

Buildings: Designing If buildings and rooms are designed by intention for sharing and multi-use, the benefits of these opportunities can be amplified.

EXAMPLES OF BENEFITS

ECONOMIC PRODUCTIVITY

Saving costs for SMEs

Small businesses benefit especially from the flexibility of co-working arrangements that do not entail commitment to long-term leases, as well as capital investments in property and equipment, and can therefore lead to operational cost savings of up to 60–75% compared to individual offices.[15]

Increasing utilisation

In London, peer-to-peer renting, better urban planning, office sharing, repurposed buildings, and multipurposed buildings, increases the value of new buildings and can double utilisation of 20% of London's buildings by 2036, saving over GBP 600 million annually.[16]

Decreasing space need

By introducing flexible working for 18,000 staff in 20% of their offices, the Lloyds Banking Group were able to remove 1,000 desks from their London offices and saved GBP 10 million.[17]

JOBS, SKILLS, AND INNOVATION

Attracting talent

Shared space offers companies the opportunity to facilitate remote working, and attract talent by meeting employee preferences for flexibility and a diverse working environment.[18]

Sharing of networks and resources

Various studies have shown that sharing space also facilitates the sharing of knowledge, networks, and resources more effectively.[19]

COMMUNITY AND SOCIAL PROSPERITY

Supporting vulnerable groups

Making space available to those who otherwise cannot afford it, and simultaneously creating stronger social bonds through space sharing, can be a way to support different vulnerable social groups in a cost-efficient manner. (See HomeShare Int. example on previous page).

RESOURCE USE

Making the best use of buildings

As building utilisation increases, cities may find themselves with more space available and a reduced need to construct new buildings – countering urban sprawl and resource consumption.[20]

ENDNOTES

1 McKinsey, *Tackling the world's affordable housing challenge* (October 2014)

2 OECD Better Life Index, *Housing*

3 Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment, *Growth Within: a circular economy vision for a competitive Europe* (2015) p. 83

4 Ellen MacArthur Foundation, *Circular economy in India: rethinking growth for long-term prosperity* (2016) p. 34

5 Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment, *Growth Within: a circular economy vision for a competitive Europe* (2015) p. 83

6 C. Kilgannon, 'This Space Available', *The New York Times* (6 September 2018)

7 For Example, cities including Paris, Amsterdam, and Berlin have started regulating commercial home sharing, which includes introducing a cap on how many days homeowners can sub-let through short-term leases. N. Lomas, *Amsterdam to halve Airbnb-style tourist rentals to 30 nights a year per host,* TechCrunch (2017); Airbnb, *New rules for home sharers in Berlin: the new housing law*, airbnb.com (2018)

8 HomeShare, *About homesharing*, homeshare.org

9 WeWork, *WeWork office space locations,* wework.com

10 A. Peters, *Hoffice turns your apartment into a free – and incredibly productive – coworking space,* Fast Company (29 January 2015)

11 3Space, *Cabinet Office, Croydon and Wimbledon*

12 HomeShare, *About homesharing*, homeshare.org

13 Spacious, *How it works*, spacious.com; N. Bowles, 'Sorry, power-lunchers. This restaurant is a co-working space now', *The New York Times* (8 July 2018)

14 DoepelStrijkers, *Circl Interiors*

15 D. White and P. White, *4 ways co-working spaces inspire innovation and collaboration*, Entrepreneur Europe (8 June 2017); S. Soni, *Makerspaces: the 'Lego' of startups*, Entrepreneur Europe (6 May 2016)

16 London Waste and Recycling Board, *Towards a circular economy – context and opportunities* (2015) p. 22

17 Arup, *The Circular Economy in the built environment* (2016) p. 23

18 CBRE, *Occupier survey report 2017* (2017) pp. 9–11

19 D. White and P. White, *4 ways co-working spaces inspire innovation and collaboration* entrepreneur Europe (8 June 2017); S. Soni, *Makerspaces: the 'Lego' of startups*, Entrepreneur Europe (6 May 2016)

20 Y. Voytenko *et al.*, *Sustainability framings of accommodation sharing*, Environmental Innovation and Societal Transitions (2017)

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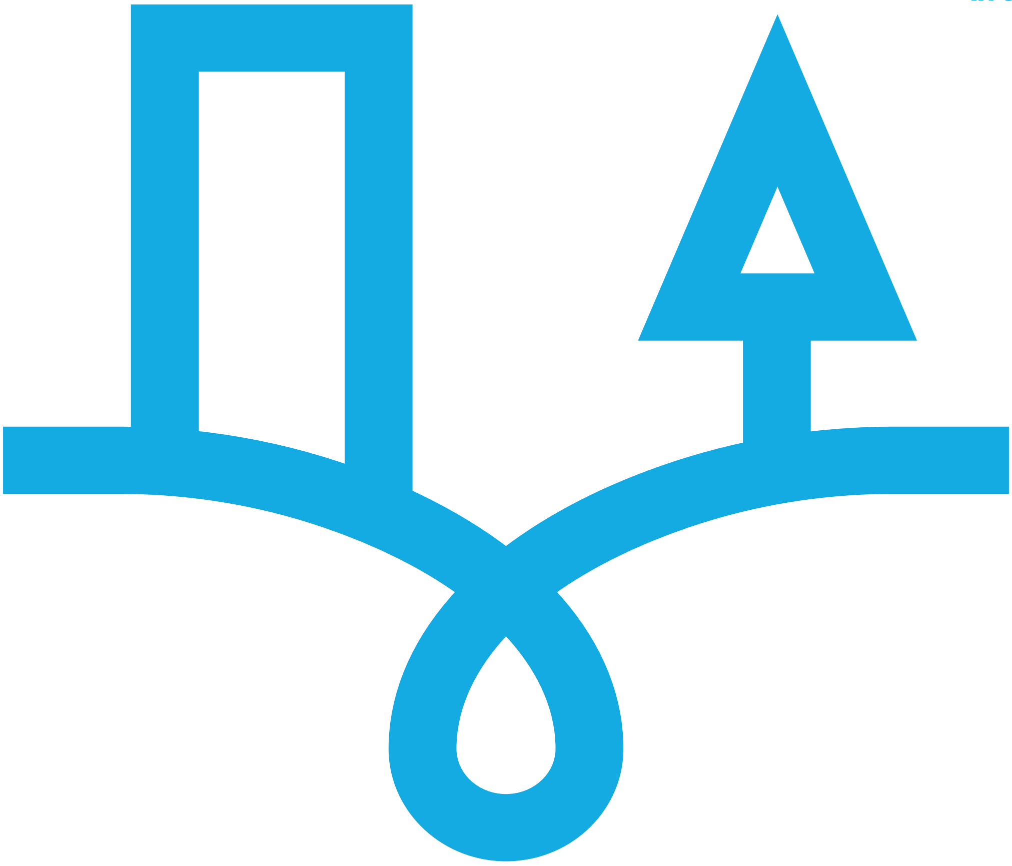
ECONOMY
IN CITIES



OPERATING AND MAINTAINING BUILDINGS FOR MAXIMUM, REGENERATIVE PERFORMANCE

ELLEN
MACARTHUR
FOUNDATION

ARUP

Reducing energy and water consumption in buildings is important in order to improve the use of resources, and to reduce operating costs and improve affordability. Predictive and timely maintenance prevents disrepair and keeps materials and components in use. For new building stock, taking appropriate actions in the design phase can ensure that buildings are energy- and water-efficient, but for all buildings (and particularly existing buildings which in many places account for a significant part of the urban building stock), ensuring good operational and maintenance practices is key. This can be significantly enabled through new business models (in which maintenance is incentivised), and smart, digital technologies.

CASE FOR CHANGE

30% of global energy consumption and **28%** of the world's energy-related CO_2 emissions are linked to the use of buildings[1]

Up to **21%** of water use in Europe happens in buildings[2]

Around **10%** of EU households struggle to pay their energy bills[3]

9/10 existing buildings in the EU will still be in use in 2050[4]

> **"In Italy between 2014 and 2015, the cost of ordinary and extraordinary maintenance works was around EUR 117 billion, while the construction sector was worth EUR 169 billion. Safeguarding existing stock was therefore equal to 70% of the building sector's entire turnover."**
>
> Antonio Disi, energy-efficiency expert, the Italian National Agency for New Technologies (ENEA) (2018)

EXAMPLES OF CIRCULAR ECONOMY OPPORTUNITIES

Using smart technology to run buildings effectively

Smart meters and connected devices can be applied in new and old buildings to optimise performance, reducing average energy and water use. Sensors can monitor the building's condition and predict maintenance needs, and prolong the building's lifespan.[5]

Using product-as-a-service models for building fit-outs

Building users can purchase building fit-out items, such as lighting, air conditioning, and carpeting, through new business models (known as performance-based or product-as-a-service business models). In these business models, users pay for the use of the products rather than the products themselves. The product-as-a-service provider retains ownership of the product and therefore also often the responsibility for the maintenance, upgrade, and take-back of the product, which incentivises improved performance, reduced operational costs, and places greater value on the maintenance and reuse of the product and components. The service provider is financially incentivised to provide solutions that are either or both reusable and durable, and energy- and resource-efficient.

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Repurposing buildings for alternative uses

To be kept in use, non-modular buildings can be adapted and reconfigured to serve a new purpose. For example, redundant commercial and public buildings can be converted into new and more adaptable spaces including housing, makerspaces, and office space. (See *Buildings: Designing)*

Refurbishing[6] buildings to run more efficiently

Refurbishing the existing building stock (which can include the opportunities above) can improve how efficiently buildings are used and operated. Refurbishing is generally less resource intensive than replacing old buildings with new ones and is therefore especially important in established cities where urbanisation has peaked and most of the building stock has already been built.[7]

RELEVANT CASE EXAMPLES

Procuring light as a service

Philips' 'pay per lux' solution provides lighting as a service to Amsterdam's Schiphol Airport on a performance contract basis. The system is designed to be cost- and resource-efficient. For example, Philips has developed specially designed light fixtures that are easier to service and maintain, making them last 75% longer than conventional alternatives. In addition, by using LED electricity, use can be reduced by up to 50%. The service operates through a collaboration between the Schiphol Group, the energy service provider Cofely, and Philips. This multi-party arrangement also enables the real-time management of the service, helping to ensure it is as reliable and effective as possible.[8]

Repurposing surplus retail space into community hubs and business incubators

Due to changes in the retail banking sector a range of Barclays' bank branches closed. This led Barclays to trial a new business support and incubator scheme in their place. Partnering with 3Space (a building management company), several empty branches were repurposed into co-working, event, and makerspaces, supporting community engagement and the growth of local start-ups. A 2,000 sq ft branch in Oxford, UK, became home to 48 start-ups and social organisations, with over 600 visitors and 29 events a month including maker meet-ups, coding classes, conferences, training sessions, innovation/technology education for the community, cultural events, and art exhibitions.[9]

Collaborative refurbishing project of municipal buildings, paid with energy savings

In 2008, Middelfart Municipality refurbished its publicly owned building stock consisting of 97 buildings (or 180,000 m^2). The project investment was DKK 44 million, and with 21% in annual energy savings generated (which exceeded the initial guaranteed savings), this investment was repaid in 10–11 years. By partnering with the energy service company (ESCO) Schneider Electric, the project was financed through a cost-neutral energy performance contract, in which the achieved energy savings covered the project investments.[10]

EXAMPLES OF WHAT URBAN POLICYMAKERS CAN DO

Asset management of existing buildings owned by the city is an important lever to ensure the efficient use of buildings. Asset managers can also inform **public procurement** to ensure maintenance work is conducted most cost effectively – for example by pooling tenders for lighting, fit-outs or refurbishment to achieve economies of scale and cost reductions. Through **legislation and regulation** some city governments can also ensure that the entire urban building stock fulfills certain energy- and resource-efficiency standards.

To explore further see **Policy Levers**

EXAMPLES OF LINKS TO OTHER SYSTEMS AND PHASES

Buildings: Designing Building design will have a significant impact on the operational efficiency of buildings and how easy they are to maintain or adapt.

Buildings: Making The use of 'buildings as a material bank' can also support the maintenance of buildings by giving owners greater awareness of the building's material content and age.

EXAMPLES OF BENEFITS

ECONOMIC PRODUCTIVITY

Generating positive return on investment

Investing in extensive energy-efficient renovation gives a good return: EUR 1 invested by the government in renovations can return up to EUR 5 back to public finances within one year.[11]

Increasing GDP

A 2012 study showed that EUR 1 billion of energy-efficiency investments, had a positive impact on GDP of EUR 0.88–1.06 billion.[12]

Increasing productivity

Improving building insulation can lead to improved thermal comfort, and therefore reap productivity benefits. A study estimates that every EUR 1 invested in insulation, results in EUR 0.78 benefit in a reduction of days missed. Productivity improvements due to better air quality can reach 8–11%.[13]

JOBS, SKILLS, AND INNOVATION

Creating jobs, skills development and increasing competitiveness

Meeting a 40% energy savings target by 2030 in the EU could create 1–2 million local, direct jobs (especially in SMEs) as well as upskilling opportunities, while improving competitiveness and innovation in the construction and energy service industries.[14]

HEALTH AND ENVIRONMENT

Reducing GHG emissions

Meeting a 40% energy saving target in existing buildings in Europe by 2030 would reduce the sector's GHG emissions by 62.9% in the residential sector and by 73% in the non-residential sector. By 2050, deep renovation of the building stock could reduce the sector's GHG emissions by 90% compared to 1990 levels.[15]

COMMUNITY AND SOCIAL PROSPERITY

Reducing energy poverty

Improving the energy performance of buildings addresses a root cause of energy poverty. Increasing homes' energy-efficiency guarantees permanent energy savings and leads to lower energy bills for residents.[16]

RESOURCE USE

Reducing energy consumption through refurbishment

Through simple refurbishment solutions, it is possible to reduce energy consumption by 20–30% in existing buildings.[17] Deep refurbishment can cut building-related energy consumption in Europe up to 80%, saving the EU over 30% of its total energy use (equivalent of 4 billion barrels annually).[18]

Saving energy through smart technology

Current smart technologies have the potential of lowering the energy consumption of buildings by 10% globally.[19]

Reducing maintenance costs and extending building life

Predictive maintenance and analytics can currently save up to 20% annually on maintenance and energy costs, while increasing the projected lifetime of the building.[20]

Reducing water consumption

A smart meter system helps the IBM factory in Burlington to cut water use by 29% or USD 0.72 million annually.[21]

ENDNOTES

1 UN Environment, *Global status report 2017: towards a zero-emission, efficient, and resilient buildings and construction sector* (2017) p. 14; International Resource Panel, *The weight of cities* (2018)

2 BIO Intelligence Service, *Water performance of buildings* (2012) p. 9

3 European Parliament, *Boosting building renovation: what potential and value for Europe?* (2016) p. 53

4 Renovate Europe, *Multiple benefits of renovating*, renovate-europe.eu

5 Arup, *The circular economy in the built environment* (2016) p. 36; Arup, *Smart city opportunities for London* (2016)

6 Refurbishing here used synonymously with renovation, deep renovation, and retrofit

7 European Parliament, *Boosting building renovation: what potential and value for Europe?* (2016) p. 22

8 Arup, *The Circular economy in the built environment* (2016) p. 41

9 3Space, *Barclays Hatch*, 3space.org

10 SparEnergi.dk, *Middelfart Kommune*, SparEnergi.dk, *Introduktion til ESCO,*

11 Renovate Europe, *Multiple benefits of renovating,* renovate-europe.eu

12 European Parliament, *Boosting building renovation: what potential and value for Europe?* (2016) p. 52

13 Ibid.,

14 Ibid., pp. 51, 52, 54,

15 Ibid., pp. 22, 51

16 Renovate Europe, *Multiple benefits of renovating*, renovate-europe.eu

17 Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment, *Growth Within: a circular economy vision for a competitive Europe* (2015) p. 85

18 European Parliament, *Boosting building renovation: what potential and value for Europe?* (2016) pp. 21, 51, Renovate Europe, *Multiple benefits of renovating,* renovate-europe.eu

19 UN Environment, *Global status report 2017: towards a zero-emission, efficient, and resilient buildings and construction sector* (2017) p. 10

20 Schneider Electric, *Predictive maintenance strategy for building operations: a better approach* (2014) p. 4

21 Ellen MacArthur Foundation, *The circular economy opportunity for urban and industrial innovation in China* (2018) p. 50