CIRCULAR BUSINESS OPPORTUNITIES FOR THE BUILT ENVIRONMENT
CIRCULAR BUSINESS OPPORTUNITIES FOR THE BUILT ENVIRONMENT

Published by the Ellen MacArthur Foundation, *A New Dynamic 2: Effective Systems In a Circular Economy* brings together 18 key thinkers, business leaders and academics who look beyond the boundaries of their respective disciplines and establish the necessary connections to re-think our current development path. This volume helps to further understand and engage in the realisation of the circular economy model.

Ellen Franconi, PhD Building Systems Engineering, is a Manager at The Rocky Mountain Institute (RMI) in Boulder, Colorado. Her work embraces integrated design principles and utilises building performance modelling and metre-based savings verification to demonstrate the business case for efficiency investment.

Brett Bridgeland is registered Architect and Project Manager II at Seventhwave. Brett provides high-performance building consulting to design teams and building owners. With experience in both architecture and engineering, he drives integrative, creative solutions that are supported by technical analysis.

BUILDINGS REPRESENT AN IMPORTANT ENERGY END-USE SECTOR WORLDWIDE.

Buildings use more primary energy than any other sector in the world and account for nearly 40% of primary energy consumption. Buildings serve as our homes, work places, and community centres. Buildings shield us from the elements and shape our lives. We spend the majority of our time inside them – turning on lights, powering up electronics, and maintaining thermal comfort. But too frequently, our behaviour regarding buildings includes tearing down relatively new ones, quickly constructing others, and failing to take a whole-systems approach in their design, products, and services. This creates some of the adverse effects that we use buildings to protect ourselves against: namely air pollution, environmental degradation, and extreme weather events.

The consultants McKinsey and Company identified building operational efficiency as the number one global resource savings opportunity, placing its value at USD 696 billion, assuming only cost-effective technologies are installed. This enormous savings potential does not even take into account natural resource savings associated with efficient use of materials in building construction, fitting out the interior, IT systems and equipment.

Eliminating waste from buildings by minimising material use and operational energy consumption to the maximum extent possible, promises cost savings and reduced risk from fossil-fuel cost volatility. Entrepreneurs have much to
gain from capitalising on this opportunity to reduce resource waste associated with the built environment. Those that embrace an innovative, circular approach can further benefit from increasing material productivity and its economic value creation.

As revealed through the 2010 McKinsey study, we routinely waste vast amounts of fossil fuels in powering and conditioning our buildings. While addressing worldwide building efficiency issues is a challenge, it also presents a business opportunity. Proven by experience, we know that engineers and architects can achieve radical resource efficiency and save their clients money by leveraging whole-system design principles (...)

**BUILDING CONSTRUCTION**

Circular end-of-life solutions are increasingly possible but still limited in applications for building structural materials. Wood structures can return to the biosphere; structural steel can be remanufactured, and in fact, is already almost entirely recycled, according to the American Institute of Steel Construction. Engineered steel kit-of-parts solutions, such as proprietary systems ConXtech or BONE Structure, can be disassembled and reassembled without remanufacture. But these systems have constraints. Lightweight wood framing is limited to low-rise structures, and large-scale timber structures have size limitations and/or reliance on supplemental steel or reinforced concrete elements, as is the case in Skidmore, Owings and Merrill’s Timber Tower Research Project.

Given a sufficient supply of steel scrap stock, steel remanufacturing could theoretically run on renewable electricity in electric arc furnaces, but it is still very energy intensive. In 2006, the steel industry used 5% of all US industrial energy, mostly in the form of fossil fuel combustion. Disassembly and reassembly of steel kit-of-parts solutions requires an after-use market for structural components, likely decades after initial construction. This can be facilitated by increasing adherence to design and construction-industry standard structural sizing. And aside from end-of-life issues, site work and heavy construction rely on heavy machinery, which today runs almost entirely on fossil fuels. To varying degrees, the systems above may rely on substructures of concrete, though innovations are underway to reduce that reliance. This is important because the cement industry is the most energy intensive of all US manufacturing industries, and today concrete down-cycles material at end-of-life.”

Due to the end-of-life challenges and inherent energy intensiveness of construction, the conversation of circularity for building structures involves matching the embodied energy of the structure with the building’s potential to provide economic value. For iconic buildings, a structure with high embodied energy can be justified due to its extended useful lifetime.

By greatly extending building lifetimes, resource leakage per product service
can be substantially reduced. For more temporary structures, more biological construction solutions involving materials with low embodied energy and requiring less resource-intensive fabrication are most desirable. As with other aspects of circular economy thinking, the selection of building construction materials represents an economic opportunity for maximising the financial return per manufacturing expenditure.

ECONOMIC DURABILITY

Circular economy concepts should be applied not only to the materials and methods used in constructing buildings, but also to space planning and real estate value propositions during the initial decision to build. With the correct foresight, a structure can be designed to nimbly endure many cycles of programmed space usage, maximising the return on initial infrastructure investment. At the end of one programme life, another programme life can begin, with very high effectiveness and no down-cycling of spatial quality or building functionality.

CASE STUDY: CHINA BUILDINGS SECTOR

These concepts are particularly important in China, where more cement was used in three years than was used in the United States in the entire 20th century. Globally, cement represents around 5% of all anthropogenic carbon dioxide emissions, and around half of that occurs in China. Strategies to reduce cement-related emissions tend to focus on the supply side, including plant efficiency, alternative fuels, limestone substitutes, or carbon capture and sequestration (CCS), but often neglect the resource savings potential on the demand side.

It is reported that Chinese buildings currently last only 30 years, serving a single function before being torn down to accommodate the next, higher value function. This is in part due to poor construction quality that forces a premature structural end of life. Worker training and high-quality construction management practices are part of the solution to this problem. The growth of the nascent Chinese prefabricated construction industry will also be important. Structural elements could be manufactured in a factory setting, under an automated, streamlined process with better quality controls and less material waste, then shipped to the site for rapid assembly. Prefabrication enables rapid, streamlined construction that reduces construction waste and improves building quality and durability.

Cases of prefabrication in China and elsewhere have resulted in lifetimes lengthened by 10–15 years, reductions in construction material loss by 60%, and reductions in overall building waste by 80%. While prefabrication is still relatively new in China, its promotion will accelerate its adoption across industry. The Broad Sustainable Building, a prefab construction firm, is claiming to be the world’s fastest builder after erecting the 57-story Mini Sky
City building in the Hunan provincial capital of Changsha. The project involved assembling three floors a day using a modular pre-fabrication method 25. The building is 80% more efficient than a standard building made of steel and concrete.

Short building life in China results from long-term land-use planning that is conducted with short-sighted or speculative single-use zoning, rather than allowing for evolving and adapting land-use patterns. A land-use planning policy that encourages building adaptability and rewards longer building lifetimes can provide both economic and environmental benefits. This careful planning is particularly pressing during China’s period of rapid urbanisation, ongoing housing reform and emerging, affluent lifestyles. The forthcoming transition to a more service-based economy demands an adaptable building stock that can accommodate ever-evolving 21st-century office concepts, laboratories, data centres, and more.