

White paper | 01.03.2024

Accelerating the transition to a Circular and Sustainable Built Environment in 2035: Role and vision of the four Dutch Technical Universities

Team

Torsten Schröder, Daan Schraven, Marc van den Berg, Tom Coenen, Vincent Gruis, Qi Han, Alexander Wandl, Emiel Wubben

To accelerate the transition of the built environment towards circularity and sustainability we need radical transformations and long-term stamina. In this white paper the 4TU.Built Environment Domain Acceleration Team Circularity + Sustainability (DAT CE + SD) presents the bedrock for developing a transformative vision for the built environment in 2035.

1 Challenges

Scientific evidence points to the urgency of an accelerated societal transformation to tackle the impacts of climate change, destruction of the biosphere, forced migration, and increasing inequalities. We are in a pivotal decade, characterized by interconnectedness of grand challenges, irreversibilities, lock-ins, and tipping points. Humanity is challenged to act now, and it is only with profound changes of socio-technical systems that we can tackle these challenges.¹

In this context the construction sector is playing a pivotal role. For example, in the Netherlands, compared to all sectors, it is responsible for approximately 50% of raw material consumption, 40% of energy consumption, 30% of water consumption, 35% of CO₂ emissions, and 40% of construction and demolition waste.² Technology and design can be considered a part of the problem (given the technological developments in the past and present), but also as part of the solution, as an integral part of the future in addressing the key societal challenges the sector is facing. To ensure that these innovations contribute to addressing the challenges, these must be considered in the context of the broader socio-technical changes, or as transitions.

The 4TUs must critically question their role and complicity in the creation of past and current problems, actively seek to overcome structural barriers in internal culture, and redirect their creative and transformative powers. Transitions require fundamental changes not only in the technologies but also in the practices and institutions that guide our behaviour. We will have to give up things, but crucially there is also a lot that we can gain from these transitions. There is an urgent need for optimism on what can be done, instead of what will become (climate change). The positive aspects need to be moved into the centre of discussions and narratives.

¹ IPCC (2023) AR6 Synthesis Report: Climate Change; IPBES (2019) global report on biodiversity and ecosystem services; International Resource Panel (2019) Global Resources Outlook 2019.

² Ministry of Infrastructure and the Environment, + Ministry of Economic Affairs. (2016). *A Circular Economy in the Netherlands by 2050: Government-wide Programme for a Circular Economy*.

This transition is complex and requires actions to cross boundaries between specialised disciplines, sectors, and stakeholders across different levels while working at different temporal and spatial scales. Although the challenges themselves are becoming clearer and the effects of denial and delaying action are getting more visible each day, we are still hampered by fundamental uncertainty how to choose between promising approaches to address these challenges. It raises questions on: How could the necessary radical changes land in society? What configurations of technological solutions lead to a desirable future? What new and adapted practices are needed to achieve such a system? How do roles of and interactions between construction stakeholders change in such a system? To address these questions, it is crucial that we take action- and design-oriented approaches, in which academia, authorities, companies, citizen and environment work together to envisage and implement desirable futures. In this quintuple helix approach, it is crucial to eventually come to collective action as an industry in transition through participation and reflection in which our DAT could play a pivotal role.

2 DAT Circularity and Sustainability

Given our distinct position to empower societal reflection, research, learning, and leadership the four Technical Universities have unique opportunity to help shape our societal values, and the narratives that drive change. As an interdisciplinary group of researchers, we unite on efforts to develop initiatives aiming at accelerating the transition to a Circular and Sustainable Built Environment.

2.1 Approach: Embracing system thinking, complexity and uncertainty

Given that initiatives to support the CE + SD transition are inevitably interconnected with other societal challenges, it is crucial that open, purposeful, and integral approaches are used to inquire, conceptualize, and construct future responses. We are working already on innovative and promising design approaches, design processes, evaluation methods, materials (chains), and contextual enablers.³ But we are still far away from large scale application and upscaling. Circularity and sustainability are high on the agenda but lack the priority to result in large-scale action.⁴

The transition towards a circular and sustainable society calls for a radical transformation, that is transdisciplinary, across diverse scales and time frames. Thus, we must embrace system thinking, complexity and uncertainty to find ways how these radical ideas could land in our societies.

The DAT starts by understanding the built environment as the arena for (co-creation) research on the ongoing transition. The circular transition is not *merely* referring to a technical change, such as using new materials or adopting new recycling technologies. We argue that the roles of design, construction, operation, maintenance, renovation, and deconstruction in essence having an impact on society, politics, responsibility, humanity and nature at large. Therefore, this wider playing field requires us to follow a quintuple helix approach for an effective circular and sustainable transition in the built environment. Thus, we build on a *broad understanding* of technology, such a broad understanding includes questions of responsibility, accountability, justice, participation, knowledge (necessary to both produce and participate), and many more. Importantly we approach technology as complex socio-technical systems that aim to address societal challenges and working for the Greater Good. We aim for responsible innovation⁵ and a mission driven approach,⁶ that distinguishes us from most innovation and transition thinking approaches developed within other industries. Envisioned

³ For instance, the BTIC Knowledge and Innovation Program (2021): Circular Design for Buildings and Infrastructure. Retrieved from https://tki-bouwentechiek.nl/wp-content/uploads/Kenns-en-Innovatieprogramma_BTIC_CirculairOntwerpen_02022021.pdf

⁴ Circularity Gap Report 2024, <https://www.circularity-gap.world/2024>

⁵ <https://www.nwo.nl/en/researchprogrammes/responsible-innovation>

⁶ <https://www.rvo.nl/subsidies-financiering/meerjarige-missiegedreven-innovatie-programmas>

transition pathways to circularity and sustainability are necessarily contested and uncertain. We must resist attempts to abolish uncertainty with simplistic explanation models that caused the failures of the mainstream modernist, technocratic institutions. Instead, uncertainty can challenge technocratic visions, and open new alternatives.

To make a more prominent contribution to circular transition we aim to do following: First, we consider the resource flows at a systemic level to account for the cross-sectoral interactions between, for example, concrete assets in infrastructure and concrete building structures. Second, beyond single technological solutions or projects, we consider the transition pathways as systemic changes that are uncertain, complex, and contested. This requires approaches that mobilize the wider stakeholder environment to anticipate next steps in the transition. And third, we aim to create long-term visions that link to missions and transition goals to provide directionality to practitioners and to allow them for making strategic choices in positioning themselves towards a circular future.

3 Setting the future agenda

Addressing the challenges is only possible when the efforts align towards a shared and aligned view of a future-proof construction sector. As universities, we are in the position to zoom out and take a systemic view on the transitions ahead. By collaboratively working on a shared agenda towards a circular future, the DAT aims to offer the perspectives needed for society and industry to change towards shared, positive future and aims to inspire, mobilize, and possibly coordinate the stakeholders in the sector.

Other parties are already taking steps in the circular and sustainable transition, we see it as our task to focus on the following cornerstones as a DAT to organize our role in enquiring, conceptualizing, and constructing a positive future, by setting out this future research and innovation agenda. Crucially the success of our agenda is dependent on support through government-wide commitment across the entire spectrum of government policy so that circular solutions can become the norm.⁷

3.1 Facilitate and steer the ongoing debate on urgency

We need to intensify the debate on urgency and identify key bottlenecks and barriers. Incremental changes, here and there, simply will not meet the challenges ahead. Nothing less than a paradigmatic change in the BE is necessary. Change in both the public and private sectors are needed to deliver circular infrastructures, buildings, and cities of the future. We must massively fast-track climate efforts on all fields of construction, all scales, and all timeframes. Addressing the challenges in the BE requires a fundamental transition, which opens new creative opportunities, fields of activity, businesses, and forms of employment. On the one hand, this demands theoretical depth and a sensitivity for context, and, on the other hand, this needs close collaboration with practice to make use of the stakeholder's expertise and increase the industry's sense of urgency to act.

3.2 Facilitate and steer the ongoing debate on values

We need to develop new methods to broaden our understanding of value within a circularity context. Value is not only economic but can be seen as a multidimensional and multilevel concept that extends to, for example, environmental and social values as well. Design, construction, operation, and demolition firms need new tools to acquire insights into these values and their contradictions.

⁷ Hanemaaijer, A., + et al. (2023). Integrale Circulaire Economie Rapportage. Den Haag: PBL
<https://www.pbl.nl/publicaties/integrale-circulaire-economie-rapportage-2023>

Resolving those contradictions is a challenge that requires new methods as well. This involves purposeful effort towards aligning the views and perspectives of stakeholders to decrease the contestation on the various values and views on circularity. A direct intersection with this view on value, is the implication that these will have on the way we view broader economic aspects such as growth, GDP, well-being, inclusion, planetary boundaries, and societal sustainability.⁸ In consequence we aim to advance debates on Degrowth / Alternative Growth in the BE by making these tangible for discourse with businesses, authorities, academia and citizens.

3.3 Methodological innovation and theory development for transitions in the built environment

How to develop and enact innovations in complex, uncertain socio-technological systems? There are competing theoretical frameworks. Promising approaches might build on systems theory, complexity theory, transition studies, 'Responsible innovation',⁹ Mission-oriented innovation,¹⁰ and Science and Technology Studies (STS)¹¹ in combination with design-led approaches to explore science and technology in its social context. Technological design brings together various forms of knowledge, diverse vocational actors, and multiple spatial and temporal scales. These fluctuating worlds do not emerge through the strict application of simple rules and guidelines, but through conceptions, initiatives, interpretations, negotiations, and choices. Thus, we need robust theoretical frameworks to explore how technological innovations take part in the social world, being shaped by it, and simultaneously shaping it.

3.4 Twin transition: circularity and digitalization

The transition towards a circular built environment coincides with the digital transitions, referred to as the 'twin transition' in the European Green Deal.¹² The combinations of the circularity and digital transitions offers new opportunities to create the future. Digital twins, track-and-trace, and other models could inform construction practitioners about the circularity potential of any buildings or infrastructures. Data and information are crucial in that regard, which poses significant quality and quantity challenges. For existing constructions, information is often inaccurate due to poorly documented changes during a lifetime (a quality problem), or it may simply be absent (a quantity problem). The causes of these problems can be traced back to the ways information is being generated, processed, and communicated by different actors in the fragmented (reverse) construction supply chains. Digital technologies are furthermore also used in few life-cycle stages only. New integral information management approaches thus need to be developed to ensure that the circularity transition can benefit from the ongoing digital transition.

3.5 Spatial turn

Current circular economy policies and initiatives are rarely viewed spatially. They ignore the important role of place and space. The circular economy must literally 'take place' and is entangled with the constant competition over the scarce resource of land. Thus, the footlessness of CE policies, initiatives and technologies needs to be overcome through a *spatial turn*.¹³ Some examples for the important role of space in the CE transition are circular building hubs, storage spaces for reused materials, and

⁸ <https://beyond-gdp.world>

⁹ <https://www.nwo.nl/en/researchprogrammes/responsible-innovation>

¹⁰ For instance, Mazzucato, M. (2021). Mission economy : a moonshot guide to changing capitalism: Allen Lane.

¹¹ Bijker, W. (2017). Constructing Worlds: Reflections on Science, Technology and Democracy (and a Plea for Bold Modesty). 2017, 3, 17. doi:10.17351/ests2017.170

¹² <https://digital-strategy.ec.europa.eu/en/policies/green-digital>

¹³ Cp. David Harvey, Edward Soja, Doreen Massey

material sorting or processing facilities for reused and growing biobased materials. Moreover, because of the ‘footloose’ perception of the circular economy, the proposed initiatives, or ideas must be integrated with other burning issues such as climate adaptation, regional innovation, loss of biodiversity, urbanisation, and social justice.

3.6 Learning from international contexts

We aim for global impact, thus environmental and societal challenges must be not only be addressed on national level to mitigate the climate crisis and other grand challenges. How can we strengthen international exchange and cooperation to accelerate the CE +SD transition across the world? How can the NL share learning, and learn from different contexts? How can we support alignment of EU and national policies and directives? What can we mutually learn from another, how can we support the global impact?

3.7 Circularity ≠ sustainability

The circular transition is not *merely* a technical or economic change. Often the concept of circular economy and the concept of sustainability are used as if they were interchangeable. But although related, the concepts are fundamentally different. In the 1990s the concept of sustainability reframed environmental politics “by arguing explicitly that goals for protecting the Earth’s lands and wildlife could not be realised except through strategies that also addressed the improvement of human well-being in conservation areas.”¹⁴ Transitions can be beneficial for some but come at a cost to others. The ‘social dimension’ (justice, social equity, gender equality, affordability, participation, etc.) is largely missing in circular approaches, thus new theoretical frameworks and practical approaches are needed to link circularity to sustainability.

3.8 Shift from designing new to updating/transforming existing

In central Europe our cities are largely built already. Thus, we need a mind shift. Designers and engineers must embrace a significant reorientation. While the design of new buildings and structures was the top priority of architecture and engineers for generations, it is now about the transformative and regenerative preservation of the existing. Large maintenance and renovation programmes are launched, for example by Rijkswaterstaat. Guidelines, knowledge, and innovation programmes must take account of this shift and follow this paradigm change.

3.9 Develop positive scenarios and future visions, show what we can gain

We are surrounded by doomsday scenarios, while we are lacking positive and inspiring visions. Building on the power of imagination we seek to advance exploring, creating, and developing future concepts and scenarios.¹⁵ In which worlds do we want to live together in future? We aim to question and analyse specific contexts in the built environment, explore emerging technologies, open new opportunities, generate forward-looking scenarios, with the aim to develop more effective and desirable approaches towards sustainable futures. With research methods and techniques, we are uniquely in the position to sketch visual representations of potential future directions. This can help

¹⁴ Schellnhuber, H.-J., Crutzen, P. J., Clark, W. C., Claussen, M., + Held, H. (2004). Earth system analysis for sustainability. Cambridge, Mass. ; London: MIT Press.

¹⁵ Hajer, M., + Versteeg, W. (2019). Imagining the post-fossil city: why is it so difficult to think of new possible worlds? Territory, Politics, Governance, 7(2), 122-134

in making these scenarios tangible, discussable and bringing clear steps forward that we could already act on in the present.

3.10 Shift funding focus

Although there is increasing attention for funding research into circular economy and a circular built environment, it is still limited compared to some of the other big sustainability challenges, such as climate adaptation and energy efficiency in the built environment. Moreover, a funding vehicle to foster the necessary co-creation between academics, professionals, policy makers and citizens is lacking. The NWA (Nationale Wetenschapsagenda) approach from the Dutch Research Council has certainly been a step in this direction, but still only funds the academic research, requiring co-funding from practice. Other funding opportunities (e.g., through RVO, Groeifonds) emphasise innovation in practice with limited funding opportunities for academic research. European funding programmes such as Horizon Europe and Interreg do provide opportunities to have significant funding for both professional and academic actors, but they emphasise international cooperation and often have limited direct impact on Dutch society. The transdisciplinary approach that is required for achieving a circular built environment, would therefore benefit from similar funding opportunities but then directed at co-creation within the Dutch context, with equal funding opportunities for knowledge institutes and industry. The 4TU DATs will call for such funding opportunities, together with among others TKI Bouw en Techniek.¹⁶

We are still far away from large scale application and upscaling.¹⁷ Circularity and sustainability are high on the agenda but falling short on action. Let's unite efforts to speed up the transition and maximise impact.

Appendix Box.

List of current actions for the DAT C+S

We aim taking a prominent position in the CE + SD transitions in the built environment. The unique opportunity to approach this is given to us in the role that our institutions play in society. We can often use the role of academia to promote a circular built environment and in so doing reflect on the role of technology and design in its contribution to society, politics, responsibility, and humanity. This demands of us an active presence in the open debate on these issues as a bridge function between the technical universities and societal challenges in practice. To advance the CE and SD transition in the BE our DAT advocates 'Design for Acceleration'.

This point of departure instils the following three for the DAT to pursue.

Action 1: Show things that work well

Based on the critical findings of, for instance ICER (PBL, 2023), develop a plan to demonstrate effectiveness of certain measures. Show promising and inspiring innovations of 4TU.Built Environment (3 examples per university) to show an opportunity horizon. How can these be upscaled?

¹⁶ On 19 July 2023 the European Commission proposed a sixth Horizon Europe Mission dedicated entirely to the [New European Bauhaus](https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/new-european-bauhaus-horizon-europe-eu-mission-pipeline-2023-07-19_en) (NEB). Source: https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/new-european-bauhaus-horizon-europe-eu-mission-pipeline-2023-07-19_en

¹⁷ Circularity Gap Report 2024, <https://www.circularity-gap.world/2024>

Action 2: Stimulate funding

Funding should be following societal challenges. Hence, independent from current available fundings scheme, the DAT needs to call and propose more transdisciplinary funding opportunities with among others TKI Bouw en Techniek.

To not lose time to address the challenges, we will in the meantime pursue ongoing opportunities for funding through the mechanisms currently in place, like:

- NWA approach of the Dutch Research Council
- Societal funds like RVO, Nationaal Groeifonds
- Horizon Europe
- Interreg

Action 3: Join forces

Potential key activity lines are:

- Within our own research projects
- Setting up a university community to find unity on the subject, with a multiple tier system with a core group of active members, second tier key representatives from the community, and the third-tier wider community and stakeholder groups.
- Inspire and actively debate technological solutions on its responsibility for society through professional, popular and academic publications.
- Organize wider community sharing platforms to debate and discuss topics and next orientation.
- Connect and maintain contact with agenda setting organisations, both national as well as European and International (TKI Bouw en Techniek (TKIBT), ECTP, etc, Ministries and funding organisations like NWO and RvO, PBL) by organizing discussion events and workshops.

For information and updates about the 4TU.Built Environment Domain Acceleration Team Circularity + Sustainability (DAT CE + SD) please visit: https://www.4tu.nl/bouw/Research/Circularity_and_Sustainability/