Digital sustainability: a recipe for unintended consequences?

The case of predictive digital twins for social housing

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Abstract

Digital sustainability is gaining scholarly attention due to the significant potential of digital technologies to help achieve the Sustainable Development Goals. Yet, this nascent scholarly field largely overlooks whether and how firms can acquire the capabilities to contain its unintended consequences. To address this lacuna, we conduct a longitudinally study of the first Dutch social housing association to apply a predictive digital twin aiming at offering tenants an energy-positive building. Through ethnographic observations, interviews, surveys, and forward-looking co-creation, we identify strategies to contain the potential unintended consequences of predictive digital twins. Our preliminary findings highlight the role of listening to 'undesirable' futures collectively and shifting communication ownership across different organization and community levels to prolong temporal attention that lasts beyond the end of a project.

Key words: Digital Sustainability; SDGs; Forward-looking cocreation; Foresighting

Introduction

Todays' most pressing grand societal challenges including climate change, biodiversity loss, and a rising socio-economic inequality, among others, are increasing in urgency and complexity (Ferraro et al., 2015; George et al., 2016; Gümüsay et al., 2020). In response to these grand challenges, a plethora of compelling technology-driven solutions have emerged to address firms' sustainability in various ways (George et al., 2021; Pan & Zhang, 2020), including supporting the reorganization of supply chains (Di Maria et al., 2022), to enable resource- and energy efficiency, and improving communities' resilience (Birkel & Müller, 2021; Tim et al., 2021), among others. In response to these phenomena, scholars have recently coined the term 'digital sustainability' to identify the substantial potential of digital technologies in contributing to organizational- and society-level sustainability goals (e.g., Stuermer et al., 2017; Pan & Zhang, 2020; George & Schillebeeckx, 2021, 2022; George et al., 2021, 2022; Bohnsack et al., 2022; Pan et al., 2022).

While the potential benefits of digital sustainability are increasingly more tangible and promising (Stuermer et al., 2017; Tim et al., 2021), such an optimistic outlook to the field is problematic, as it risks overlooking important unintended consequences of digitalization (Bohnsack et al., 2022). The impacts of digital technologies may be ambiguous, and initial empirical insights are raising ethical concerns, revealing unintended consequences that may outweigh potential benefits. These include the case of a paradoxical increase of carbon footprint as a result of ICT technologies in manufacturing (Itten et al., 2020), and consumer lock-in (Acquier et al., 2017). Despite this initial evidence, our understanding of unintended consequences as a phenomenon is still limited in the emerging field of digitally-enabled sustainability (Bohnsack et al., 2022). More specifically, what remains ambiguous is what capabilities are required by firms to manage and mitigate the effects of unintended consequences, and how these capabilities can be developed alongside the uptake of digital technologies to prevent the consequential emergence of unintended consequences. In this paper we analyze the case of a social housing association attempting to transition part of its portfolio into energy positive buildings by means of predictive digital twins. A predictive digital twin is a digital representation, or simulation, of a physical entity's behavior that keeps updating through its lifecycle, and can be used to optimize choices in the physical world. It is supported by technologies such as IoT sensors, smart algorithms, machine learning and cloud services, to allow for optimalization (Liu et al., 2021).

This case is revelatory (Eisenhardt & Graebner, 2007) as it illustrates an important and relevant type of organizational effort towards implementing digital solutions to tackle climate change in the context of the built environment in general, and for social housing in particular. In the Netherlands, social housing associations are well-established aiming at providing adequate dwellings to households with lower incomes. This context is relevant because it may uncover potential unintended negative social and ethical consequences through the adoption of digital technologies (e.g., Andersen et al. (2021); Acquier et al. (2017)) as it deals with marginalized groups at risk of suffering negative impact of sustainability (Eikelenboom & Long, 2022). We investigated potential unintended consequences of the predictive digital twin technology and explore how the social housing association managers organized for these potential future scenarios. This was done by means of action research (Greco et al., 2023) to enable forward looking co-creation (Sharma et al., 2022). Forward looking co-creation takes the future seriously (Wenzel, 2022), allowing researchers and practitioners to tackle wicked problems for which solutions do not yet exist, by collaboratively imagining and interrogating futures (Gümüsay & Reinecke, 2022).

Theoretical background

Unintended consequences, sustainability, and digitalization

Unintended consequences are a known phenomenon, almost inevitably manifesting as a result of any social action in any complex system (Merton, 1936; Vernon, 1979; Vaughan, 1999). While unintended consequences might also have a positive side, leading to unexpected benefits, the unforeseeable outcomes that are of concern consist of unanticipated drawbacks and perverse effects (Boudon, 2016). Most modern technologies have negative consequences that are both unavoidable and unpredictable. Yet, the unintended consequences concerning sustainability efforts might be less forgiving given the urgency of sustainability challenges (Bohnsack, et al., 2022; Greco & Long, 2022). Simultaneously, the sustainability crisis itself can be largely defined as an unintended consequence of human and business' activities (Bansal, 2019). For example, almost all environmental problems, from chemical pollution to global warming, are unintended consequences of the application of modern technologies. Traffic congestion, deaths and injuries from car accidents, air pollution, and global warming are unintended consequences of the invention and large scale adoption of the automobile. Resistance to infections in hospitals is the unintended side-effect of the overuse of antibiotics, and even human population growth

leading to environmental degradation is the side effect of various technological (i.e., agricultural and healthcare) revolutions. Because of the complexity of ecosystems, deliberate changes to one part of the ecosystem, such as environmental interventions, will often have negative unintended consequences in other parts of the ecosystem. Sometimes, these effects cause permanent irreversible changes, which is why managing and organizing around understanding and mitigating unintended consequences is of utmost importance. The study of unintended consequences requires scholars to take the future seriously and put it at the center of research activities rather than at the periphery (Wenzel, 2022). This includes understanding how to perform and construct distant futures (Augustine et al., 2019), and develop knowledge into how actors mobilize in constructing persuasive and actionable temporal frames, managing the chronology between a dominant past and a recognized yet unknown future (Nyberg et al., 2020).

Preparing for the future through forward looking co-creation

"*History is merely a list of surprises. It can only prepare us to be surprised yet again*."

Kurt Vonnegut

To grasp and anticipate for the unknown effects coming from societal challenges firms need to form imagined futures and create fictional expectations (Beckert, 2021). Future-related methods and techniques, such as strategizing, forecasting and project organizing, are used in order to control and even try to de-problematize the future (Wenzel et al., 2020). Yet many of these techniques stand at the periphery of projecting historical and present trends into the future, altering it through different scenarios and possibilities. Forward-looking co-creation (Sharma, et al., 2022) seeks solutions that do not exist yet and can only emerge collectively shifting the time horizon from present, to future.

Research Context: Sustainable Positive Energy Neighborhoods

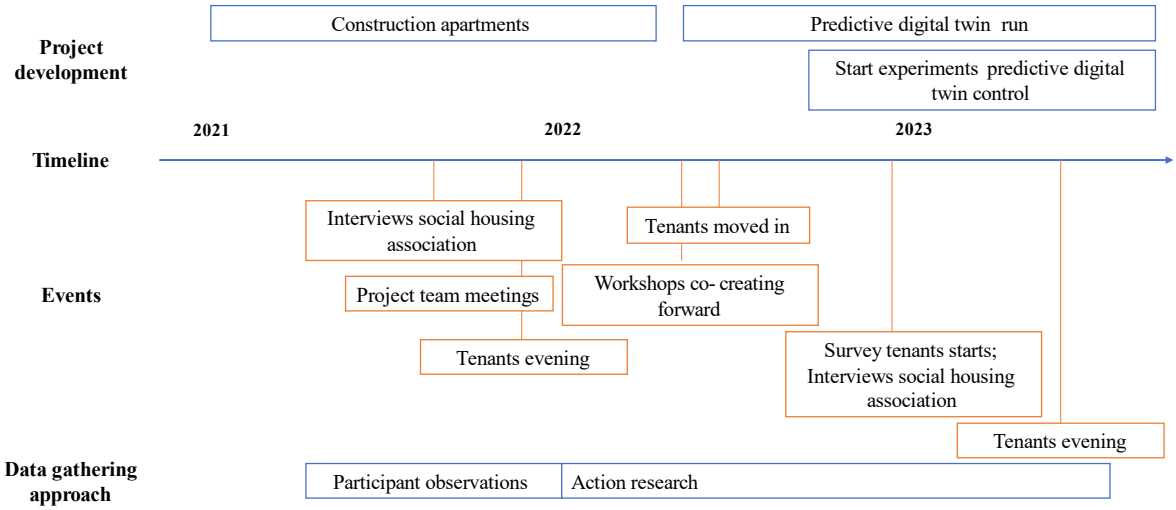

Figure 1 Research timeline and data collection

The context of this research is a 4-year co-creation initiative formed by research institutes and companies located in four different countries in Europe, Norway, Spain, Austria, and the Netherlands, representing different climate zones, to create Sustainable Positive Energy Neighborhoods (SPENs). SPENs do not exist yet. They are theoretically possible, according to renewable energy calculations and the principle of energy sharing (Salom et al., 2021), but have not yet managed to materialize in the present. In each country of the initiative a different technology is being developed, prototyped, and implemented in the actual construction of an energy positive set of buildings within a neighborhood. In the Netherlands, the focus is on the pilot of a predictive digital twin which is a key enabling technology for energy positive neighborhoods to enable "peak shaving" – leveling out peaks in electricity use by consumers – which is one of the main barriers to the realization of SPENs. A predictive digital twin can also considerably improve energy efficiency whilst maintaining the thermal comfort of inhabitants, resulting in lower energy bills for the tenants, if not revenue generation, and improve overall occupant satisfaction. The social housing association joined the consortium in 2019, planned the construction of a building complex with 39 apartments in 2020, and started building in 2021. The construction was ready by March 2022, and the first inhabitants moved in by the summer of 2022. Using an abductive approach (Dubois, & Gadde, 2002), we started the field work with the question: *How do the social housing association managers organize for imagined futures?* (Figure 1). Given all the unknowns in the project we decided to engage in action research aiming at leveraging value reciprocity and impact temporality (Greco, et al., 2023). We initially engaged in informal interviews with the project partners, and in participant-observations.

Between March and December 2021 we observed the project team meetings of the social housing association, and the tenant meetings. Throughout the development and implementation of the predictive digital twin, concerns started to arise regarding the value proposition of the service and the impact of the predictive digital twin on data privacy, fairness of electricity supply, distribution inequality and issues relating to user feedback. Therefore, we organized workshops with the intention to co-create forward-looking scenarios. In October 2022, we started an experiment to monitor the use of the predictive digital twin, with the goal to optimize its performance. In December 2022 a survey among tenants was conducted, investigating user experiences with the new technology. In addition, we held interviews with the project managers at the social housing association. In early 2023 we will observe additional tenants evenings.

Research Insights

"*Does it mean you are going to know every time I take a shower?*"

Future Tenant, December 2021

Collective listening to imagined undesirable futures

Observations and interviews show that tenants have on multiple occasions shared concerns regarding data privacy. The predictive digital twin collects data on apartment occupants behavior in order to optimize energy usage in the building. At the beginning of the project, it was unclear to the tenants how their data would be protected. Tensions in data privacy are contradictory because of the uncertain use of data. As highlighted by one project manager working on this project "*sometime tenants are funny, they worry about their privacy but they are sharing their whole life on TikTok* " (October 2022). Yet, the consortium partners are aware of the importance of privacy concerns which go beyond collecting data on individual tenants. A lack of data privacy could potentially lead to systems unfairness: "*How fair would it be if this technology would fall in the hands of a grid operator who then learns everything about users' consumptions and peak demands and thus increases prices at dinner time?*" (Digital Twin Engineer, January 2022).

Initially, the predictive digital twin was intended to inform the use of sustainable installations (e.g. heat pumps, PV panels, etc.) to improve efficiency. Yet, during one of the tenants' evenings, one of the tenants asked "*does it mean that you'll collect tons of data about how much energy we use but we will not know about it? Shouldn't we be aware so that we can adjust our consumption accordingly?*" (December 2021). Initially, the social housing organization

intended to not share the data, in order not to trigger technostress: stress experienced by end users of digital technologies (Ragu-Nathan et al., 2008). The objective of the predictive digital twin is to ensure that the apartment complex produces more energy than it consumes. However, current legislations in The Netherlands makes it difficult to share PV panels among apartments, as currently energy bills and production are managed at the household level. Therefore, the engineers and architect designing the energy systems of the SPEN, decided to connect each apartment to a specific set of PV panels on the roof. While this was done to equally distribute energy production, an unintended consequence of this design approach could be energy inequality. Not every PV panel has the same sun exposure, some are more in the shadow and some have a sub-optimal orientation. Other PV panels might accumulate dirt as a consequence of their orientation to the wind. Distribution inequality is a concern as the location of PV panels affects the amount of energy that is produced for a certain apartment. Since Dutch social housing boasts a long tradition of mitigating and containing unintended consequences (Greco & Long, 2022), the project partners were open to adapting their approach to their customers' concerns to take into account these imagined undesirable futures, and social housing association managers started up a new communication and participation initiative for their tenants.

Manage contradictory futures by shifting communication ownership

Past approaches to tenants' communications involve hierarchical communication as opposed to co-creation (Greco & Long, 2022). Social housing associations may fear co-creation "*What if we cannot provide what the tenants ask? We will have very angry clients"* (Strategy manager social housing, 2021). Yet, for interventions to the building, communication is a crucial process, and social housing associations need to receive permission from 70% of their tenants in order to make changes to a building such as energy retrofits, according to a Dutch law (Rijksoverheid, 2022). This had led social housing associations in the past to keep the communication purely informative and top-down, while highlighting mainly the positive aspect of building intervention, such as energy savings, lowering energy bills, and better indoor comfort, and omitting those that could generate discussions. But tenants' stress towards changes can increase due to implications of the new technology, changes to their habits and new things that need to be learned.

To address these challenges, in this project the social housing association decided to pilot what they call the "Maatschappelijk Mooi" initiative, which translates "socially beautiful", in which they used a novel tenant recruitment policy. They decided to rent 19 of the 39 apartments to (young) adults with a mental and/or mild intellectual disability, and the remaining apartments

to people seeking social housing. Typically, tenants who are assigned a dwelling have to have been registered to a waiting list. In the socially beautiful initiative, the first 10 tenants were recruited based on their motivation letter to be ambassadors, who are willing to help other residents in need and be a reference point for these other tenants with disability and all the other tenants. The ambassadors are important stakeholders for imagining and explicating potential concerns based on their understanding of the future possibilities brought about by the predictive digital twin, and they had the opportunity to actively influence the development of the plans. They have set additional requirements, which has resulted in adjustment of the overall design. The goal of this concept was to create a pleasant living environment where residents, together with the neighbors, ensure a good atmosphere, and look after each other. The remaining home seekers are also required to join and actively contribute to a sustainability-focused residential community with all residents. Throughout the first years of the predictive digital twin pilot, these ambassadors are serving as a communication point, substituting part of the role that has traditionally been taken by the social housing association, but being a peer group as opposed to an entity in a position of power.

Discussion

Predictive digital twins are a new technology that may enable buildings to become sustainable through energy efficiency gains, potentially resulting in Sustainable Positive Energy Neighborhoods (Liu et al., 2021). However, there is an urgent need for research into the unintended consequences of such technologies, and measures to mitigate them such as whether and how firms can acquire the capabilities to preemptively identify negative consequences and design them out of projects (Bohnsack et al., 2022). In this paper we have engaged a group of researchers, managers, and users into forward-looking co-creation to design new approaches to navigate the tensions emerging from possible future unintended consequences. This approach to research desirable futures, requires a paradigm shift in the way scholars approach data gathering, moving from seeking evidence of phenomena occurred in the past, to gathering data of what could be and imagining alternatives for a desirable future (Gümüsay & Reinecke, 2022). Unintended consequences are yet to occur, surprising, and difficult to foresee (Bohnsack et al., 2022). As such, the study of how something that does not exist yet can be managed, needs to rely on forward looking co-creation (Sharma, et al., 2022; Gümüsay & Reinecke, 2022). Waiting until problems occur and the solving them retrospectively is not only costly but also insufficient for meeting urgent sustainability challenges in the built environment. Our initial

findings uncover the practices of imagining “undesirable” futures, which is abductively connected to the notion of imaging positive, desirable futures (Gümüsay & Reinecke, 2022). Another new practice we identified that collectively identifies negative unintended consequences, is the shifting of communication ownership through different organizational and community levels, to break the tradition of a hierarchical, top-down communication typically adopted by social housing associations. This study contributes to the emerging literature on unintended consequences of digital solutions to the sustainability crisis, as it offers a case example of collective, forward-looking imagining that could be applied in many different contexts.

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