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Article

Co-Creating the Future with AI: From Input to Ownership in Participative Scenario Generation: A case study from the Swedish recycling industry

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Abstract

Participatory and co-creative elements are key in foresight processes to change mental models, and to promote futures literacy and instill ownership of the results. With the emergence of AI tools, and their suggested use in foresight, recent work has suggested that generative AI provides a promising avenue for AI-assisted scenario generation. In the current study we design and test a workshop methodology to increase the participatory aspects of scenario creation via the use of generative AI. The workshop was carried out as part of a strategic foresight project on the future of recycling systems for the Swedish municipality Borås.

Keywords

Scenarios, Generative AI, Participative Processes

Introduction

With current disruptions in the world, from geopolitical tension to the impact of climate change, there is a need to engage decision-makers and stakeholders in foresight processes to break out of the myopic perspectives that are prevalent today. While short time horizons in decision-making are not new, it is becoming increasingly important to shift cognitive lock-ins that prevent people from considering the long-term future in order to help organizations and society thrive. Reports have found that peoples' levels of imagination have declined over time, leading some to declare that we are living in a crisis of imagination (Mulgan, 2020), partly because we lack the tools and context where we can imagine the future – gaps that participatory foresight can help fill.

With the foresight process resting on two assumptions: 1) that the future is not determined, and 2) that decisions and actions taken today can influence how the future unfolds (A. D. Andersen & Andersen, 2017), there is a need to create the enabling conditions for participants to embody these assumptions. Part of the solution is to empower people with the tools and agency to engage with the future through scenarios, and particularly in the co-creation of images describing the future (Miller, 2007). While foresight has a history of participative processes, outlined in more detail below, participants should also be present in the co-creation of the material to help establish new mental models of what is possible (Wack, 1985). An early proponent of a co-creative approach to scenario generation, Kees van der Heijden suggested that anchoring of scenarios requires a degree of participation in the process, making the scenario development a collaborative practice. Achieving this sense of buy-in and ownership of the scenarios is important for both the distribution of scenarios in an organization and their use in strategic planning (Rowland & Spaniol, 2022; van der Heijden, 1996). This approach is echoed in the Futures Literacy Hybrid Strategic Scenario method (FL-HSS), which emphasizes stakeholder inclusion and rigorous imagining to challenge assumptions about the future and support present-day decision-making (Miller, 2007). Achieving this requires a systematic creativity to move beyond the probable and preferable to imagine the possible (Rhisiart et al., 2015). The questions are how

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we can bridge the imagination gap to reach this level, and get stakeholders to feel ownership of the future?

The answer could come down to novel technologies. With foresight's long history of tracking and assessing emerging technology, and its potential for disrupting our current ways of working, technological advancements — from machine learning to generative AI — now offer a genuine opportunity to spur imagination and transform foresight processes (Spaniol & Rowland, 2023). The challenge for foresight practitioners is to find ways in which to use the technology available to advance the field of foresight, and enable more people to use foresight and develop futures literacy (Miller, 2018).

This paper aims to explore how stakeholder engagement in participative foresight processes can be combined with new technology in the form of generative AI, to aid in the construction of scenarios and help engage people in the future. We begin by describing the theoretical context of participatory processes and foresight research, before exploring the emerging literature on emerging AI tools and methods to increase the automation of foresight. Through a case study we test how generative AI can be used together with participants in a scenario workshop, and what lessons we can learn from that.

The study contributes to the foresight literature by examining the impact of novel technology not only on practitioners, but also on participants in foresight processes, with relevance for both business settings and broader collaborative contexts.

Participative and Co-creative Elements in Foresight

The concept of participatory processes in foresight emerged around the 1970s when Alvin Toffler published his book *Future Shock*, describing how people will be struck by future shock as our society undergoes rapid changes in short periods of time (Toffler, 1970). Toffler proposed Anticipatory Democracy as a process combining citizen engagement with awareness of the future to counteract such shocks (Bezold, 2019). (Bezold, 2010). (Bezold, 2010). The related concept of deliberative democracy similarly gathers citizens and leaders in dialogues around grand societal challenges, prioritizing long-term perspectives over political short-termism (Dryzek & Niemeyer, 2019).

In addition to the above-mentioned anticipatory democracy and deliberate democracies, concepts such as participatory foresight (Faucheux & Hue, 2001), anticipatory learning (Stevenson, 2002) and inclusive foresight (Loveridge & Street, 2005) have been established over time. They share the common starting point that participative processes together with stakeholders create better conditions for change and anchoring of new ideas, with the latter being a central aspect in most approaches. Benefits of stakeholder inclusion, apart from the anchoring of the process, is that participants often have knowledge in the area of work – knowledge that can sometimes be difficult for the scenario experts themselves to obtain. However, this also means that the opposite could pose a problem, where participants do not have a complete knowledge of the area of work, which could lead to the creation of unrealistic images of the future have little relation to the underlying structures of the world (Andersen et al., 2021).

Foresight processes tend to be participatory in that stakeholders take part in the co-creation of results, from the content of scenarios to the consequences, and strategies or changes needed to meet the anticipated changes (Gidley et al., 2009). Participative creation of scenarios can vary across context, scenarios can be developed by experts based on stakeholder knowledge, which are then anchored with stakeholders (Wesche & Armitage, 2014), or that participants are presented with material from researchers in the shape of trends, drivers, or challenges that participants react to, process, and propose scenario drafts from (Madlener et al., 2007). Commonly in these processes the scenario experts use the initial input from participants, such as prioritized trends, and write a number of scenarios that are presented back to participants for further development (Cairns et al., 2013; Gidley et al., 2009). A weakness in this approach is that the writing of the scenarios remains a black box for stakeholders, who only provide input and later get an output in the form of a set of scenarios. While participants still co-create the material and provide input into which scenarios that should be prioritized, the foresight experts do most of the writing.

Foresight practitioners have long recognized that unanchored material risks being "like water on a stone" (Wack, 1985). The risk of not using participatory processes is that the process and results do not inspire the change that was intended. Decision-makers who feel no ownership over the material are unlikely to act on it (Gidley et al., 2009) – consistent with behavioral science evidence that creative participation strengthens ownership (Norton et al., 2012).

The path towards automated foresight

While current development and use of AI in foresight is relatively recent, work pertaining to computational models for anticipation and foresight dates back more than a decade (Mühlroth & Grottke, 2018). Early applications used machine learning to mine patents for trend identification, including Lent et al. (1997) and subsequent work mining scientific publications (Tho et al., 2003), with later work extending these approaches to map research trends and emerging issues (Sasaki et al., 2016) and emerging trends in technology foresight that can be explored further (Li, 2017).

The concept of data-driven scientific discovery as a new paradigm (Hey et al., 2009) — a milestone in data-driven scientific discovery — laid further groundwork for computational foresight, with the prospect of near-zero-cost knowledge acquisition through massive dataset mining (Abeles, 2012).

Trend scanning and weak signal analysis remain the areas where machine learning has been most extensively applied in foresight to date (Vignoli et al., 2022). As data volumes grow, practitioners increasingly need to have systems in place to make sense of relevant information (Rozanec et al., 2023). Geurts et al. (2022) have suggested a hybrid AI-expert approach to make use of the increasing amount of data and emerging AI technology to strengthen foresight processes, while retaining the important role of the expert in the process and emphasizing a participatory approach. The approach lays out an interactive process between the AI and the expert, where data mining and modelling is continuously fed into the traditional foresight process all the way from scoping through to strategizing. The authors suggest that the approach can help to broaden the range of hypotheses about the future that can influence participants' strategic conversations.

In terms of describing and visualizing the future using novel technologies, recent work has suggested that generative AI provides a promising avenue for AI-assisted scenario generation. Spaniol and Rowland (2023) have written a comprehensive review, outlining the potential of using AI to assist in the creation of scenarios. They suggest that generative AI can aid in the creation of scenarios and help aid the scenario process by providing practitioners with a narrative structure to build on. However, the use of generative AI still requires practitioners to act with care, and not pass of AI-generated scenarios as their own or fail to quality control the output. It is further important to consider what the use, and who the user is, of the scenarios created, so that material is not created without no specific use or user in mind (Spaniol & Rowland, 2023).

Generative AI can further be of assistance in the visualization of scenarios, which can be an important part in communicating results to people in organizations who were not part of the process, as a way to bring the future to life, or to communicate the scenarios to a wider audience (Rozanec et al., 2023). Recent work has used generative AI to visualize scenarios created through a Delphi process, demonstrating that text-to-image models can be used to depict the future and make illustrations of scenarios more easily attainable (Di Zio et al., 2023).

Using AI to engage and co-create in foresight

In the current paper we aim to combine a participative scenario generation with generative AI to test how participatory processes can be enhanced via the use of new technological tools. As described above, participation is a key element in foresight processes, and the idea that the future is something that can be shaped and influenced is a key tenet in foresight (A. D. Andersen & Andersen, 2017). However, how generative AI can be leveraged to engage participants and the anchoring of results from a scenario process has currently not been studied.

Prior work in AI and foresight consistently emphasizes the role of human experts — using generative AI as a co-pilot rather than an autopilot (Geurts et al., 2022; Spaniol & Rowland, 2023). Reducing human involvement risks undermining the mental model challenges central to foresight (Crews, 2019), and may trigger rejection due to lack of ownership (Piller & Antons, 2015).

We posit, based on previous research, that a process where participants can give their input into the scenario creation will generate a stronger level of engagement and feeling of ownership of the results (Norton et al., 2012; Piller & Antons, 2015), and that generative AI can be used to develop usable scenarios towards this end (Spaniol & Rowland, 2023).

Case Study from the Swedish Recycling Industry

Our exploration of AI-assisted scenario generation come from a project conducted on behalf of a municipal energy and environmental company, aiming to explore the impact of trends, drivers, and future developments on the design of forthcoming recycling systems for household and small business waste in a Swedish city.

Three workshops were conducted with the 12-person management team, alongside experts in foresight, waste management, and circular economy, supplemented by desk research and expert interviews. This paper focuses on the second workshop, in which participants co-created scenarios using generative AI as input for subsequent strategy and roadmap development.

Methodological approach

The project involved a full-day scenario workshop aimed at crafting alternative future scenarios for strategy formulation, supplemented by a post-workshop survey to gather feedback on the scenario process. These scenarios were intended to inform strategic development. As input into the workshop a set of trends were used that had been developed in a previous workshop, together with the same set of participants that took part in the scenario workshop meaning that the trends were well-known to them. The trends were divided across seven trend themes, each with two to three trends in each theme in a morphological box, see Table 1.

Table 1. Morphological box of themes trends used in the scenario workshop.

Trend themes	Trends		
Product design	Cleaner materials & simpler compositions	More complex materials & compositions	
Reuse	Increased reuse & recycling of products	Limited reuse & recycling of products	
Sorting	Simplified source sorting, disassembly, and fewer fractions - increased post-sorting	More complex source sorting, disassembly, and more fractions - reduced post-sorting	
Traceability	Digital tracking is possible for most product and material types	Digital tracking is only possible for a few product and material types	
Recycling	Materials and products are recycled to the greatest extent possible	The majority of materials and products continue to be recycled through energy extraction	
Responsibility Distribution & Ownership	The individual manages the majority of recyclable resources and waste	Producers and private entities manage the majority of recyclable resources and waste	The public sector manages the majority of recyclable resources and waste
Energy access	Energy abundance, low prices	Energy uncertainty, volatile prices	Energy poverty, high prices

Prior to the workshop, the researchers created a set of two scenarios using the trends from the morphological box using ChatGPT 3.5 to use as input into the scenario workshop. The scenarios were created in the same way as they were to be developed in the workshop to create a comparable set of futures. The pre-made scenarios were titled *The circular evolution* and *Waiting for action*, descriptions of these scenarios can be found in Appendix A.

Scenario workshop

Ten individuals from the management team took part in the workshop, which was scheduled over a full day in a physical setting. The workshop was conducted in Swedish, and as such all trends and scenarios were originally created in Swedish and have been translated to English for this article. The scenario development was conducted in the following steps.

In step one, participants were initially separated into two groups. Each group was provided with a pre-constructed scenario, *The circular evolution* and *Waiting for action*, designed to acquaint them with the content and format the types of scenarios used in foresight. Participants read the scenario independently, and then came together within their respective groups to discuss and reflect collectively on the scenarios.

In step two, participants were asked to evaluate the scenario using a set of prepared questions. These questions focused on the impact of the scenarios on the municipal energy and environmental company. Examples of questions discussed within each team in relation to the scenario included: *'What new capabilities and resources need to be developed?'* and *'Which capabilities and resources should receive less focus?'*.

In step three, the groups were instructed to develop two new scenarios using the morphological box. Initially, they familiarized themselves with the trend themes and potential future directions of the trends outlined in the morphological box (Table 1). Each group proceeded to select one future direction from each of the seven themes. This selection resulted in a total of seven chosen future directions for each group, which collectively formed the basis of their respectively scenarios. Following this selection process, they named their respective scenarios *EU's most sustainable circular city* and *Tough match*.

In step four, the facilitator converted the selected sets of trends and their corresponding future directions into prompts (Table 3). These prompts were inputted into ChatGPT to generate initial drafts of the scenarios. The drafts then underwent further refinement through additional prompts, aiming to sharpen the descriptions and pinpoint potential consequences. While these scenarios were being generated in ChatGPT, the participants attended a presentation and were not involved in the live prompting process. After their creation, the scenarios were presented to the various groups for evaluation, using the approach described for the pre-made scenarios in step 2, collectively reflecting on the resulting scenarios and evaluating their impact on the future recycling system.

During the workshop, participants documented their thoughts and reflections on post-it notes, responding to the questions outlined in step 2. The groups then shared their thoughts and reflections with everyone present. Following the workshop, the facilitators consolidated the thoughts and reflections, which served as the foundation for development of a roadmap and strategy work.

Post-workshop survey

A survey was sent to participants in the weeks following the workshop to assess their experiences of the scenario process, the use of ChatGPT to create the scenarios, and their own memories of the workshop and feelings of ownership of the results. The survey (Table 2) was structured to assess participant's memories of the various scenarios, in order to see if they remembered the scenarios they helped create during the workshop better, or if they formed a preference for their own scenarios.

Table 2. Post workshop survey. An overview of the questions and response formats used to assess participants' experiences of the scenario co-creation.

Question		Answer format
1.	Describe your impressions and memories from the scenario workshop	Open text
2.	I feel that the workshop gave me new perspectives on how to work with, and envision the future	Scale of 1 (completely disagree) to 5 (completely agree)
3.	How well do you remember the content of the four different scenarios?	Open text
4.	Which scenario do you believe captured the possible future in the best way?	Participants selected one option from the list of scenarios
5.	Which scenarios did you work with during the workshop?	Participants selected up to two options from the list of scenarios
6.	What do you remember about the scenarios you worked with?	Open text
7.	By actively creating a scenario during the workshop I started to feel ownership over it	Scale of 1 (completely disagree) to 5 (completely agree)
8.	The method for developing the scenarios during the workshop was clear and easy to understand	Scale of 1 (completely disagree) to 5 (completely agree)
9.	Using ChatGPT during the workshop added value to both the process and the end results	Scale of 1 (completely disagree) to 5 (completely agree)

These questions were included to assess whether participants would be biased towards the scenarios they helped create, or if all scenarios were valued and remembered equally. While it will be desirable for the co-creation of scenarios to enhance the engagement of participants, it would be less desirable if participants discarded alternative images of the future in favor of their own creations.

Results

The results are divided into two parts: the first part describing the process of generating scenarios in a participative setting using generative AI, and the second part describing the participants' perceived experiences of the process and their reported level of engagement.

Scenario process

Two scenarios were co-created with participants during the workshop. As mentioned above, the scenarios were generated by entering a set of trends and their future direction from a morphological box, selected by participants, as prompts into ChatGPT. A summary of the prompts and the resulting scenarios can be seen in Table 3.

Table 3. Prompts used for ChatGPT and the resulting scenarios. Prompts were based on participants' selection of trends from the morphological box.

Title	**EU's most sustainable circular city**	**Tough match**
Prompt	Write a future scenario for recycling given this information: Increased national/regional supply of resources and materials Materials and products designed with more complex compositions Increased reuse and recycling of products Simplified source sorting, disassembly, and fewer fractions but increased post-sorting of products and waste Digital tracking is possible for most types of products and materials Materials and products are recycled to the greatest extent possible The public manages the majority of recyclable resources and waste There is an abundance of energy and low energy prices	Write a future scenario for recycling given this information: Increased global supply of resources and materials Growing demand for secondary resources, which are cheaper than virgin resources Materials and products designed with complex compositions Increased reuse and recycling of products More complex source sorting, disassembly, and additional fractions, with reduced post-sorting of products Digital tracking is possible for most types of products and materials Materials and products are recycled to the greatest extent possible Producers and private entities manage the majority of recyclable resources and waste Energy uncertainty prevails, and electricity prices are volatile
Scenario	In 2045, recycling has become a completely different process than it was a few decades ago. With increased national/regional supply of resources and materials, it has become possible to reduce dependence on imports. At the same time, the design of materials and products has continued to become increasingly complex, requiring innovative solutions for efficient recycling. Thanks to increased reuse and recycling of products, the need to produce new materials and products has decreased significantly. It has also become easier to recycle materials and products through simplified source sorting, disassembly, and fewer fractions. However, despite this, the need for post-sorting has increased due to the increased complexity of product design. With digital tracking of materials and products, it has become possible to monitor the entire recycling chain more efficiently. There is ample access to energy, and chemical recycling has gained momentum on a large scale. The public has taken on a greater role in the management of recyclable resources and waste, contributing to a more efficient and sustainable resource management.	In 2045, increased global supply of resources and materials has led to a growing demand for secondary resources, which are now more affordable than virgin resources. However, this has also triggered a race to extract the last valuable raw materials from nature. Materials and products have become increasingly complex with advanced compositions, making recycling and reuse more challenging. Source sorting, disassembly, and fractionation have become more intricate, resulting in reduced recycling efficiency. While digital tracking is possible for most products and materials, it has not been sufficient to compensate for the complexity of these materials and products. Producers and private entities have taken over the management of recyclable resources and waste, leading to a lack of coordination and efficiency in recycling systems. Simultaneously, energy uncertainty and volatile electricity prices have created problems for recycling systems.

ChatGPT generated two distinct scenarios based on the input, where the trends were either the same (i.e. *Increased reuse and recycling of products* being used as input in both scenarios) or in the opposite direction in the two scenarios (i.e. *There is an abundance of energy and low energy prices* used as input in the scenario *EU's most sustainable circular city*, and *Energy uncertainty prevails, and electricity prices are volatile* being used as input in *Tough match*). With the similarity in the input-trends, it is perhaps not surprising that the scenarios came out somewhat similar in style and semantics, with the content differing in the direction of specific trends. Neither of the two scenarios were seen as complete after being generated by ChatGPT, but were revised and further probed by the workshop facilitators together with participants. The creation of the scenarios further helped spark a discussion among the participants, as in the case of one scenario ChatGPT interpreted one or more of the trends as positive developments, whereas some participants had considered them negative.

In consideration of each scenario, participants engaged in discussions covering a wide array of topics including values, behaviors, technological advancements, emerging industry stakeholders, resource management, policy, legal aspects, and the prioritization of specific capabilities. For example, in the Tough Match scenario, there was a consensus on the necessity to enhance leadership within networks and ecosystems of stakeholders, while reducing emphasis on energy production. Similarly, in the scenario EU's most sustainable circular city, participants discussed the importance of intensifying efforts to expand specific material recycling and enhance the capacity to market and sell reused raw materials, while diminishing focus on combustion and broad recycling centers. As such, the co-creation of scenarios in the workshop was successful as it resulted in a set of alternative images of the future that were sufficiently different from each other to result in ideation and discussions among participants.

Participants' experiences

Six participants replied to the survey assessing their experiences of the workshop, giving us an answer rate of 60%. The results from the survey are summarized in Appendix B. Overall, participants agreed with the statement that the workshop gave them new perspectives on how to work with and envision the future. This indicates that the process was successful in providing participants with new perspectives on foresight, which is not surprising, as participants were new to foresight and had learned new ways of working with the future throughout the project. Looking at potential biases and preferences for scenarios participants had created themselves, we found that these were limited and mostly non-existent.

Participants tended to agree that the active creation of the scenarios in the workshop contributed to feelings of ownership of the material, while also agreeing that the use of ChatGPT added value to the process and end-result. However, the process was being experienced as somewhat confusing, as participants rated the clarity of the method and scenario development closer to neutral though still verging on agreeing. Overall, this indicates that the method had the intended effect by instilling a sense of ownership over the results, and to engage participants in a process they felt contributed with value to the results and the overarching process (see Appendix B for the full results from the survey).

In terms of biases and memory effects in the scenario creation, only 50% of respondents believed that the scenario they helped create captured the future in the most accurate way suggesting that creating a scenario does not bias participants to believe in it more than other scenarios. In terms of memory for the various scenarios, participants rated that they remembered their preferred scenario insignificantly higher than other scenarios (Table 4).

Table 4. Mean memory ratings for participants' preferred and created scenarios with standard deviation (SD) in brackets.

	Preferred scenarios	**Other scenarios**
Memory rating	3.17 (SD = 1.33)	3.06 (SD = 1.08)
	Own scenario	**Other scenarios**
Memory rating	3.8 (SD = 0.84)	3.4 (SD = 0.43)

Similarly, there was a slight difference in the memory ratings between scenarios participants had helped create compared to the other scenarios, with the former receiving a somewhat higher memory rating. While a small difference, it is expected that participants will form better memories of material that they have spent more time processing (Craik & Lockhart, 1972).

Discussion

In the current paper we have shown that the use of generative AI as a participative scenario generating tool is useful, both in the speed of scenario generation and level of co-creation. The process of constructing scenarios can be made more transparent and accessible for stakeholders using generative AI, and adds to the feeling of ownership of results. However, facilitators still needed to lead participants through the process and to validate results, to ensure that scenarios generated hold a sufficiently high standard and challenge the current status-quo. The results are in line with previous work in the area, suggesting that generative AI can be useful for creating first drafts of scenarios that are then further developed by foresight practitioners (Karle, 2023; Spaniol & Rowland, 2023). Generative AI should thus, so far, be used as a co-pilot rather than an autopilot. The study thus practically implements a hybrid AI-expert foresight approach (Geurts et al., 2022) with an added co-creative dimension. A strong emphasis on co-creation and participation in foresight research (Andersen & Andersen, 2017; Faucheux & Hue, 2001; Stevenson, 2002) affirms that new tools can meaningfully lower barriers to participation and futures imagining.

One of those benefits is making the scenario creation process less like a black box for participants, marking a step away from the expert created scenarios by putting more powers into the hands of participants (van Notten et al., 2003). In the current study scenarios were created to aid an organization in their strategic decision-making, though this process could be extended to larger groups in settings with communities vulnerable to climate change (Cairns et al., 2013; Wesche & Armitage, 2014). The approach could equally support deliberative democracy contexts (Dryzek & Niemeyer, 2019) where expert-led processes may not be feasible, with a facilitator guiding AI-assisted scenario creation at lower cost.

Despite the promise of using generative AI in the development of scenarios, some issues remain. One is that while we remove one black box of the scenario creation process by having participants being part of the creation in a workshop, generative AI models themselves can be considered black boxes in this process. We are in essence replacing the scenario expert with generative AI, both of which will have their own biases when creating the scenarios (Lucy & Bamman, 2021; Rowland & Spaniol, 2021; Schirrmeister et al., 2020). As such, while participants can more easily get hands on in generating scenarios, the writing itself remain a somewhat opaque process.

A second limitation is the criticism that has been levied against the use of generative AI in foresight processes that the results being generated, be it text or images, are built on already existing information (Spaniol & Rowland, 2023). We are in essence using the past to project into the future. This raises the question as to whether current generative AI models can create something truly novel, as the output is based on a combination of existing sources. At the same time, recent research suggests that widespread use of large language models may reinforce dominant patterns in language and reasoning, potentially leading to more homogenized ways of thinking as both outputs and users converge around the same underlying data and model structures (Sourati et al., 2026). In a time where it is being reported that levels of imagination are in decline (Mulgan, 2020), and uncertainty as measured by the World Uncertainty Index (Ahir et al., 2022) and geopolitical risks (Caldara & Iacoviello, 2022) have been increasing, there is a dire need to ensure that images of the future are not simply continuations of the past or present as these might not go beyond today's way of thinking and challenge peoples' mental models. Additionally, while AI-assisted scenarios based on information from the past can generate images of the future, so-called anticipation for the future, the process with current generative AI-models lack the ability to handle anticipation for emergence (Miller, 2018). In essence, by only using past information generative-AI might struggle to detect and incorporate novelty into responses, or fully make sense of unfolding uncertainties that could have bearing on the both the short- and long-term future. For example, geopolitical shocks such as Russia's invasion of Ukraine — with documented impacts on material resource access (Izzeldin et al., 2023; Pata et al., 2024), energy (Chen et al., 2023; Cui et al., 2023), and environmental sustainability (Pereira, Bašić, et al., 2022; Pereira, Zhao, et al., 2022), which would be relevant for a study looking at the recycling industry. A counterpoint, in light of the present study, is that the content of scenarios should reach a sufficiently high level of deviation not only from the present and each other, but from participants mental models (van Notten et al., 2003). That is, if we are trying to influence the mental models and engagement of stakeholders that are not used to working with foresight, it could be sufficient that the described futures stretch participants thinking about the future and provide novel perspectives for them.

Further research

The current study has a relatively small sample and could be considered a pilot test in the use of generative AI to increase participant engagement in scenario generation, and further work with larger sample sizes would be beneficial to understand the extent to which the current results would generalize to other settings. Additional research could also explore ways in which participants engage with generative AI in scenario processes, as compared to non-AI processes to make more direct comparisons between approaches, and gain a more in-depth understanding of how generative AI benefits the scenario process.

Future work could incorporate validated instruments measuring foresight capabilities — such as futures consciousness (Ahvenharju et al., 2018) and episodic future thinking (Miloyan & McFarlane, 2019) — administered before and after workshops to measure the impact of AI-assisted methods on participants' capacity to think and work with the future. Regarding the AI-generated scenarios themselves, further analysis of narrative content would help assess the extent to which generated scenarios are sufficiently orthogonal. A key open question is whether and when the process could shift from co-pilot to full autopilot mode — and whether that would democratize foresight or risk hollowing out the critical thinking at its core.

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Appendix A. Description of pre-made scenarios used in the study

Title	**The circular evolution**	**Waiting for action**
Prompt	Write a future scenario for recycling given this information: • Cleaner materials & simpler compositions • Increased reuse & recycling of products • Simplified source sorting, disassembly, and fewer fractions - increased post-sorting • Digital tracking is possible for most product and material types • Materials and products are recycled to the greatest extent possible • Producers and private entities manage the majority of recyclable resources and waste • Energy uncertainty, volatile prices	Write a future scenario for recycling given this information: • More complex materials & compositions • Limited reuse & recycling of products • More complex source sorting, disassembly, and more fractions - reduced post-sorting • Digital tracking is only possible for a few product and material types • The majority of materials and products continue to be recycled through energy extraction • The public sector manages the majority of recyclable resources and waste • Energy poverty, high prices
Scenario	The year is 2045 - the EU has taken significant steps towards a circular future with the support of political measures. The design of products has undergone major changes in the circular society. Reuse and recycling are now common behaviors in society where new services for collection and repair are offered. Products are now designed with cleaner and simpler materials, where standardization has played a crucial role in facilitating recycling. This change has led to simplified sorting at the source and reduced the need for disassembly, as well as fewer waste fractions. At the same time, the need for post-sorting has increased for several material streams. The management of recyclable resources and waste has shifted from public entities to producers and private actors. These actors now see waste as a critical resource. This has led producers to adapt their business models and create incentives to develop products that are easier to recycle and reuse recycled materials for the development of new products. Digital tracking has also played a significant role in making recycling more efficient. By using technological solutions, products and materials can be traced throughout their lifecycle. This has enabled companies to track their own resources in the value chain and identify the best methods for recycling them more efficiently. As a result of increased demands for material recycling, chemical recycling has become an increasingly important part of the circular system. This has created increased availability of recycled raw materials and reduced the need for extraction and production of virgin resources. With these changes, actors specializing in different types of material streams and individual fractions have emerged. However, Sweden faces challenges in energy supply, causing volatile electricity prices, but advanced energy storage systems have been developed to balance energy consumption.	The year is 2045 - the EU finds itself in a situation where there is great discord among member states regarding whether to prioritize the circular economy or not. Despite some progress in certain areas, it is generally slow to implement political decisions, and there are many obstacles to overcome. Reuse and recycling of products account for only a limited part of society. At the same time, one of the biggest challenges is energy supply, where lack of investment has led to high electricity prices, creating a general sense of energy poverty in society. Product design has moved towards more complex materials and compositions, creating challenges for efficient recycling. Alongside this, there has been an increase in the number of waste fractions, which has placed higher demands on source sorting and product disassembly, but has also reduced the need for post-sorting. However, it is still a challenge to achieve transparency in the recycling chain, and for many types of products, digital tracking of materials and products is not possible. Due to increased complexity in product design and energy poverty, increased material recycling has become a challenge. Therefore, a significant portion of materials and products are still recycled through energy recovery, which has been an important national strategy in a time of limited energy resources. The management of recyclable resources and waste is mainly handled by municipalities and public entities responsible for collection and sorting, before being sold to reuse, recycling, or incineration operators. An important development is that it has become easier for citizens to recycle through self-service and service at municipal recycling centers.

Appendix B. Participants' responses to the post-workshop survey. Scenario A = Tough match; B = EU's most sustainable circular city; C = The circular evolution; D = Waiting for action. Summary statistics include the mean (x̄) and standard deviation (SD) for the quantitative data.

PP	Describe your impressions and memories from the scenario workshop	I feel that the workshop gave me new perspectives on how to work with, and envision the future	How well do you remember the content of the four different scenarios? A	B	C	D	Which scenario do you believe captured the possible future in the best way?	Which scenarios did you work with during the workshop?	What do you remember about the scenarios you worked with?	By actively creating a scenario during the workshop I started to feel ownership over it	The method for developing the scenarios during the workshop was clear and easy to understand	Using ChatGPT during the workshop added value to both the process and the end results
1	Somewhat vague and abstract but interesting.	3	3	4	4	3	A	A & C	A bit, but not much	4	3	4
2	Energy! Motivating! Important! Feeling needed!	5	4	5	4	4	B	B & D	A bit gloomy, but we can make a difference if we help each other. You get many good thoughts and new "eyes" by working with different colleagues.	4	4	4
3	It was exciting. Fun to get many different perspectives - it became clear that we all had very different views, but that these could be categorized into similar scenarios. Educational.	4	1	1	1	1	D	No response	Almost nothing.	3	3	4
4	Generated great engagement and viewpoints from different angles. Fun with AI.	4	3	4	3	4	C	B	Difficult to set aside personal opinions and drive the scenario.	4	4	5
5	Good methods were used during the workshop.	4	3	3	3	3	C	B	No response	4	3	4
6	Good.	4	3	4	3	3	B	B & C	No response	4	4	5
Summary		x̄=4.00; SD=0.63	x̄=2.50; SD=2.12	x̄=3.25; SD=1.50	x̄=3.00; SD=1.73	x̄=3.25; SD=1.73				x̄=3.82; SD=0.41	x̄=3.50; SD=0.55	x̄=4.33; SD=0.52