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Using the low-tech concept to create scenarios: an analysis of its potential to design for sustainable urban future

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Abstract

Designers must be equipped with methods to contribute to sustainability transitions. Scenario planning arose as approach to integrate future uncertainties while the low-tech concept promotes technological discernment. This paper looks at how low-tech fuelled scenario planning. Analysing institutional and archetypical scenarios shows a partial integration through high and low-tech extremes. However, more nuanced considerations are lacking. This paper shows that low-tech can bring an interesting dimension to future scenarios and thus contributes to method development for sustainable design.

Keywords: scenario, low-tech, archetype, uncertainty, socio-technical systems

1. Introduction

Today's environmental complexity and socio-economic challenges - also coined 'grand challenges' (De Smedt, Borch and Fuller, 2013) require rapid development of systemic solutions across areas. Urban areas are key polluters, define the quality of life and access to opportunities for 60 percent of the world's population, but are at the same time the arena for new solutions, both in terms of climate change mitigation and adaptation (Chen et al., 2021). Simultaneously, many deep future uncertainties complexify the process of designing systemic solutions to such challenges. How many people will live where tomorrow? What will their needs and social practices be? What technologies will evolve? To design suitable solutions today, these future uncertainties must be considered in engineering design practice today.

One of the most common methodologies is the use of scenarios, defined as a set of distinct, plausible and possible future alternatives, usually supported by a narrative (Spaniol and Rowland, 2019). These approaches are used during concept ideation, use case development, and various other design processes that can benefit from creative inputs by, e.g., situating participants or users in possible future situations. Moreover, companies are urged to address sustainability risks, which can be achieved by combining management and scenario planning through mixed forecasting and backcasting stages (Schulte, Villamil, and Hallstedt, 2020). The orientation of industrial innovation systems towards sustainability is indeed vital and can benefit from future scenarios (De Smedt, Borch, and Fuller, 2013; Schulte, Villamil, and Hallstedt, 2020). This paper aims to introduce to the design community the promising dialogue and collaboration between design and scenario planning which both share their focus on sustainable and socio-cultural changes. It is highlighted in Selin et al. (2015) as follows: *'scenario sets render explicit the assumption a design and/or a designer have made of the future context their design is expected to inhabit'*.

Various types of scenarios exist. A recent variation of scenarios introduces the concept of low-tech (LT) as a response to the technology-centred movements of recent decades. The underlying goal is to reduce excessive use of technology while questioning the actual need for technology in a given context.
This paper analyses the current state of LT scenarios and proposes some pathways for creating them, while outlining potential future research. The guiding research question is: *'To what extent is the LT concept integrated into scenario-based foresight?'*. To answer this, we first provide a summary of recent academic and institutional conceptualisations of LT applied to a spatial 'system' or urban area. Next, we recall the concepts of future scenarios and archetypes (section 2). After exposing the research method (section 3), two analyses are conducted (section 4): i) archetypal scenarios are analysed to understand to what extent the LT concept is integrated so far, and ii) five sets of institutional scenarios for 2030-2050 are analysed. Building on the outcomes, we finally identify some research potentials linked to generating future scenarios integrating the LT concept (section 5). Enabling a more structured integration of the LT concept in engineering design can help to simultaneously integrate increasing (deep) future uncertainty in design processes while considering LT contexts and solutions to design more sustainable and resilient solutions or create solutions that fit into larger sustainability system transitions. This paper's contributions to research are twofold: 1) An overview of the LT concept and its application so far in design and foresight. 2) Several promising research topics on integrating LT into scenario making. This shall enable future application of LT foresight in practice.
The LT concept is still in its infancy. Just as in innovation, LT applies as much to a result (an object, a system) as to the approach to achieve it such as in engineering design. Different authors mention the following concepts: LT objects (Girard et Reyes, 2023); LT principles (Bihouix and Mc Mahon, 2014) attached to a LT approach (Bloquel et al., 2022); LT systems like buildings or cities (Lopez et al., 2021; Bloquel et al., 2022; Marry, 2023) (Table 1).

Table 1. Low-tech (LT) concepts

LT…	Reference	Associated concepts
LT principles	(Bihouix and Mc Mahon, 2014)	Question needs; De-mechanisation services; Balance performances and conviviality; Reduce resource consumption, improve repairability, durability; Relocate while taking scaling effects into account
LT system	(Bloquel et al., 2022)	Utility; Accessibility (easy to understand, affordable); Sustainability (low impact, long-lasting, resource-saving)
LT approach	(Bloquel et al., 2022)	Question needs; Question techniques, technology, discourse on progress; Look to well-being and conviviality; Develop technology-saving solutions; Share knowledge on LT tools; Favour collective resilience (local vulnerability; shortage risks)
LT city	(Lopez et al., 2021)	Just sufficient; Conviviality; Sustainable management of resources; Appropriate scale

The foundation of the LT line of thought can be traced back to the 1970s. Two visions are at the origin of the concept (Bloquel et al., 2022): on the one hand the respect of planetary boundaries, on the other the need for a techno-critique discourse on current developments, also coined 'technological discernment'. To characterise a LT company and business model, Chaudemanche (2023) emphasises the necessary empowerment of people, who are more directly connected to technological developments through an enhanced appropriation. One of the consequences of this search for autonomy is the central use of open-source approaches (Chaudemanche, 2023).
Although LT approach and frugal innovation share many commonalities, they do not seem to pursue the same objective. Frugal innovation promotes, in the first place, the satisfaction of needs for 'Base of the Pyramid' people whose financial means are very limited (Albert, 2019). LT approaches are aiming at bringing solutions to local needs while remaining 'accessible, transferable, empowering and convivial' (Girard and Reyes, 2023). A LT approach is therefore an *'innovating, inventive approach to design products, services, processes or systems which maximises social utility while maintaining the*

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environmental impact below local and planetary boundaries' (Bloquel et al., 2022, p. 22, translated by authors). This paper further relies on the actionable part of concepts in Table 1, i.e. LT principles (Bihouix and Mc Mahon, 2014).

Scholars compared the LT city to other concepts for future cities like smart and resilient cities (Lopez et al., 2021). At the urban scale, digital technologies show two distinct faces: 1) the promise to optimise the use of resources for better environmental performances, but also 2) the risk of major rebound effects and loss of conviviality for urban dwellers. The Urbalotek[1] project deserves attention since it provides an attempt to translate the LT approach initially applied to products to the urban or regional scale. Four main principles structure the LT city: just sufficiency, conviviality, sustainable management of resources, appropriate scale (Table 1). According to Marry (2023), the LT city is *'a new proposition of utopia, which places at its centre technical discernment, sobriety and conviviality'* (Mary, 2023, p. 107). An in-depth analysis of 13 concepts of cities emphasises a marked opposition between smart and LT cities (Lopez et al., 2021).

2. Background

In this section, two seminal concepts used in future studies and scenarios planning are described: future and archetypal scenarios. This allows building a foundation of the integration of LT principles to strategic foresight in design.

In line with previous work (Gall et al. 2023), this paper builds on the definition of future scenarios by Spaniol and Rowland (2019): a representation of a possible and plausible future which 1) takes a narrative form; 2) embeds characteristics of the future; 3) refers to a set of external forces; and 4) coexists with other alternatives to form a scenario set. The generation of consistent and contrasted scenario sets is a demanding exercise. It requires knowledge as well as significant human and time resources. Designers can circumvent this barrier by getting their inspiration from existing scenarios in the same domain or generic scenarios called 'archetypes' and adapt them to the case study (Gall et al., 2023). The quality and suitability of scenarios to an applicative case study can be verified by using established checklist-based quality guidelines (Gall et al., 2023).

Scenario archetypes refer to a grouping of several scenarios deemed similar (Boschetti et al., 2016). The archetypes show recurrent images of the future, whatever the field of application may be (e.g., future of work, education, transport). Based on their naming, these archetypes can be characterised through various angles like the driver of a scenario (e.g., market or technology); an attitude (e.g., local governance); a resulting state or a transformation (e.g., decline). Archetypes are the results of different types of meta-analyses. Boschetti et al. (2016) compared a meta-analysis of existing scenarios generated by experts and the formalisation of shared cultural myths collected among a sample of lay people in Australia. Fergnani and Song (2020) renewed the four archetypes created by Dator (2017) by analysing a sample of hundreds of science fiction films. They created a set of six scenario archetypes which are described at a national as well as local city level, making them more tangible. The application case is the future of work in South Bend (USA). On the one hand, archetypes have the potential of simplification and understandability of complex issues in time and space for policy makers or practitioners; on the other hand, oversimplifying future visions can also be a threat. Fergnani and Song (2020) also point out that being transformative and challenging with archetypes is not an easy task because a fair distance needs to be taken from the status quo. Table 2 gives an overview of acknowledged scenario archetypes. These are presented as scenario sets.

Table 2. Examples of scenario archetypes

Reference	Name of archetypes
Dator, 2017	(Continued) Growth; Collapse; Discipline; Transform(ation)
Fergnani and Song, 2020	Growth & Decay; Threats & New Hopes; Waste worlds; The Powers that Be; Disarray; Inversion
Miskolczi et al., 2021	Grumpy old transport; At an easy pace; Mine is yours; Tech-eager mobility

[1] https://www.build-green.fr/ville-low-tech-le-projet-de-recherche-urbalotek/ [accessed 14 Nov. 2023]

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3. Research method

First, the authors conducted a systematic literature review based on the concepts of future scenarios and LT. Combinations of LT and scenario as well as LT and vision were searched for in all abstracts in the Web of Science (WoS) database on 9 September 2023[2]. This resulted in 263 abstracts that were reviewed with their titles. In the first round of review by the second author, 22 articles were identified with reference to low-tech scenarios. A more detailed analysis by both authors resulted in the selection of eight articles for full-text analysis. Of these, a further two were excluded due to the lack of discussion of future scenarios. The remaining six articles deal with LT scenarios from different perspectives. The second part of the literature review consisted of a qualitative analysis of scientific and grey literature (i.e., institutional reports):

1. Qualitative analysis of scenario archetypes based on the meta-analysis of Boschetti et al. (2016)
2. Qualitative analysis of five institutional scenarios

For the first step, five conceptual and semantic dimensions of analysis are extracted from the state-of-the art on the LT approach: questioning of actual needs (Dimension [D] 1), conviviality and autonomy (D2), technological discernment (D3), resource saving management (D4), locality and appropriate scale (D5). The second part of the research – the discussion of the LT concept in existing scenarios – is based on a sample of institutional reports publicly commissioned. The key selection criterium was having at least two scenarios to produce contrasted visions as opposed to a unique normative viewpoint. All selected scenarios are created for a mid or long-term future beyond 2030. They are either multi-sectoral or sector-specific (e.g., mobility, energy). Focusing on the French context, the study relies on three French reports and two additional common references in the sustainability transitions field. These are the scenarios of the Intergovernmental Panel on Climate Change (IPCC) and those of the International Energy Agency (IEA). The objective of this part is to analyse how *LT has so far been used in combination with scenarios (archetypes or institutional).*

4. Results

This section starts the LT scenarios found in the literature review. It is followed by an analysis of the key concepts relating archetypes and LT scenarios. Next, selected institutional scenarios are discussed through the lens of LT.

4.1. Low tech scenarios in literature

Hejazi et al. (2013) refer to HT (High-tech) and LT scenarios but equate HT with high Gross Domestic Product (GDP) development, and LT with lower economic growth, thus rather LT by necessity. A little more elaborate, Sarlak et al. (2021) create several scenarios and link the LT concept to traditional agricultural practices, showing the advantages of mixing traditional LT solutions with new technologies for optimal performance. Another simplified perspective is that of Alexander and Yacoumis (2018), which limits itself to the field of energy consumption in a LT lifestyle, where LT means low energy consumption. Kostakis et al. (2023) present mid-tech as a concept that attempts to bridge the two extremes through various elements of both approaches (application in open bionics).

Two articles looked in more detail at different versions of LT scenarios. Camilleri et al. (2022) created a HT scenario and two LT scenarios. Of the latter, one focuses on active mobility such as walking and cycling and the other mainly on local mobility, with people living and working more locally. Finally, Bauwens et al. (2020) look at the future of the circular economy in four scenarios. They cross HT and LT polarities with centralised and decentralised governance regimes, thus providing another dimension to the LT scenarios. LT equate with limited research and development investments in this study. This

[2] Search query: AB = (Low Tech Scenario) OR AB = (Low Tech Scenario) OR AB = (Low Tech Vision) OR AB = (Low Tech Vision). Articles were included when LT and scenario were referred to as defined in this paper and excluded when it referred to more technical meanings, e.g., as negative opposite of HT development.

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review has shown that although some articles already discuss so-called LT scenarios, the literature is so far limited and, with two exceptions, rather uses the LT concept to describe other phenomena.

4.2. Analysis of archetypal scenarios

In their meta-analysis, Boschetti et al. (2016) deducted several axes which can represent the critical uncertainties in existing foresight studies (Table 3). They emphasised a similar naming of the axes, which are related to critical uncertainties. The uncertainties appear along two axes in a 2*2 matrix. We investigate to what extent the archetype axes are correlated to the dimensions of a LT approach.
Applying the five earlier established dimensions (D1-D5) resulting from the literature review, a common theme in some of the studies is the questioning of needs of the society where there is a change of consumption patterns (D1). D2, conviviality and autonomy, appears in studies 1-5 and 8. For example, the search for autonomy at an individual or collective level is discussed in studies 4 and 5 and solidarity in study 1 and 2. Technological discernment (D3) can be found in studies 2 and 7. Especially study 7 refers to a slow-tech change, compatible with the LT vision instead of a technology-driven one. The fourth dimension D4, resource saving management, appears partially in study 3 and mostly study 8. The latter builds scenarios based on the scarcity of resources (in this case water resources). Finally, locality and appropriate scale (D5) is referenced partially but limited in studies 1-3, and 6. The first three studies look at global or regional dominance, the latter being closely related to more place-based and localised approaches. Study 8 refers to the cooperation as one extreme on one of the axes with a stronger role of locality in cooperation. However, across all studies, locality and appropriate scale are considered only in a limited manner.

Table 3. Exemplary archetype axes based on (Boschetti et al., 2016)

Study	Axis 1	Axis 2
1 (Busch, 2006) and 2 (Kok et al., 2011)	Global – Regional	Self-interest – Solidarity
3 (De Vries, 2007)	Global – Regional	Material – Socio-technical welfare
4 (Makropoulos et al., 2008)	Interdependence – Autonomy	Individual – Community
5 (Pinnegar, 2006)	Interdependence – Autonomy	Consumerism – Community
6 (Curry and Schultz, 2009)	Bottom-up – Top-down	My identity – Our identity
7 (IEA, 2003)	Fast – slow tech change	Unconcerned – Concerned
8 (Raven, 2014)	Cooperation – Isolationism	Abundance – Scarcity

As an intermediate conclusion, the construct of the archetypes seems partially compatible with the LT concept. Optimism or pessimism related to technology appear to be a foundation of the myths of the future currently shared through values and beliefs (Boschetti et al., 2016). Moreover, Fergnani and Song (2020) make a clear distinction between local and global impacts. This illustrates that scenarios are affected by local or global trends. In the case of LT, it seems that the local considerations dominate against global conditions.

4.3. Analysis of institutional scenarios

To apply the LT principles in an analysis of actual scenarios, five illustrative sets are presented in Table 4. Apart from the five scenarios from French General Council for the Environment and Sustainable Development (Conseil général de l'environnement et du développement durable; CGEDD), all French scenarios are compatible with carbon neutrality according to the National Low-carbon Strategy. In this framework, national orientations are given to reduce the carbon footprint of consumption and reach carbon neutrality by 2050. Low-tech is quoted as exact term in studies by Ademe (2021) and Grandjean et al. (2021), whereas 'low-technology' can be found in CGEDD (2022).

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Table 4. Characterising the selected institutional scenarios

Reference	Horizon	Topic	Scenario names
(Ademe, 2021)	2050	All sectors – 2050 Transition(s)	(translated by authors) 1-Frugal generation*; 2-Territorial cooperation* 3-Green technology; 4-Restorative gambling*
(CGEDD, 2022)	2040-2060	Sectoral	(translated by authors) 1-Basic ambition; 2-Worst climate 3-Technology push; 4-Hyperconstraint 5-Sobriety push; 6-Technological challenge* 7-Societal challenge*
(Grandjean et al., 2021)	2050	Sectoral	1-Sobriety* 2- Pro-techno*
(Chen et al., 2021)	2050-2100	All sectors	(selection) 1-Current Policies; 2-Moderate Action 3-Gradual; 4-Strengthening 5-Net Negative Emissions; 6-Renewables 7-Low-demand; 8-Shifting Pathways (SP)
(IEA, 2022)	2050	Sectoral	1-Net Zero Emissions by 2050 2-Announced Pledges 3-Stated Policies
* Compatibility with low-carbon national strategy			

Among the four 2050 scenarios developed by the French Agency for Environment and Energy (Ademe, 2021) 'Frugal generation' clearly advocates for a LT lifestyle. The following descriptors are mentioned: search for sense, frugality (chosen or constrained), preference for a local governance and industrial development (closer to needs), reuse and repair, massive renovation of buildings. The next scenario 'Territorial cooperations' is also connected to LT principles, in a lesser extent through the development of sharing economy, local markets, and renovation. The two other scenarios show diverging dynamics, where consumption patterns continue to augment while jeopardising the resource management. One of the important questions is raised for the two first scenarios: how to ensure that a substantial reduction of consumption remains equitable without prejudicing the more modest part of the population?

In 2022, the CGEDD published the results of a national prospective study for 2040-2060 on the mobility of people and goods (including maritime transport), looking at the urgency of climate change and the acceptability and social equity of transition paths (CGEDD, 2022). The study resulted in five exploratory scenarios (forecasting) and two normative scenarios compatible with the 2050 carbon budget (backcasting). The main thrusts of the various scenarios, i.e., the development of technologies and changes in behaviour associated with mobility, seem to be in line with the LT concept, while raising questions about the use of technology and the right need for it. The 'Sobriety push' and 'Societal gamble' scenarios point to a sharp drop in mobility due to several factors: fewer journeys, teleworking, modal shift towards active modes, public transport, car sharing, etc. The report also raises several fundamental questions, such as: Are radical sobriety objectives possible without technology? What social equity is there in the quest for sobriety between the 'hypermobile' and those who travel less? How can we challenge lifestyles that favour immediacy, massive reliance on deliveries and a negative impact on the logistics sector?

The Carbone4 study (Grandjean et al., 2021) proposes two contrasting and credible scenarios for national infrastructures excluding buildings (mobility, energy, digital, carbon sequestration), with a view to resilience and the restoration of natural ecosystems. The 'Sobriety' scenario includes elements associated with LT thinking. For each sector of activity, this scenario advocates the control of consumption and a strong moderation of usages (i.e., energy, mobility). The local dynamic is based on short supply chains. This scenario directly integrates tensions over raw materials by, for example, adopting a wait-and-see stance on the deployment of carbon sequestration solutions. Conversely, the

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'Pro-techno' scenario is based on a very high level of technological maturity, which may conflict with supply issues. The macro-economic simulation results show much more limited infrastructure investment in the 'Sobriety' scenario.
Next, the eight representative concentration pathways linked to IPCC scenarios are analysed. They result in estimated global average temperature increases between 1.5 and 4 degrees Celsius by 2100 (Chen et al., 2021). The trajectories listed in Table 4 are narrative descriptions that focus on different elements, such as examining the effects of current policies or achieving net negative emissions. Although LT does not appear as such, various references are made to related concepts. For example, the 'Low demand' scenario refers to more local actions and changes in consumption patterns, while the 'Shifting Pathways' scenario also refers to behavioural and local actions and highlights the possible impact of resource-efficient urban areas.
Finally, three similar scenarios have been created by the IEA (2022). Two of them analyse energy demand and associated emissions for already expressed policies and announced commitments, while the last one focuses on the goal of achieving net zero emissions by 2050. In the sectoral analyses, this lens is used to see what combinations of policies and technologies are needed to get there. Again, LT is not used as such but appears in certain elements. For example, the report states that for the transport sector, *'behavioural changes will have a greater impact than any other measure in 2030, representing a level of difference in energy demand'* between scenarios, while *'the energy savings from electrification will become more meaningful after 2030, and the average fuel consumption of a car on the road will be more than four times higher in 2050 than today'* (IEA, 2022 , p. 156). This is one of the many examples that demonstrate the complementarity of HT and LT elements in sustainability transitions.

5. Discussion

This article began with a search for the intersection between LT and scenarios. The LT trend is part of a broader dynamic that can be linked to the fourth industrial revolution, focusing more on local development and energy distribution, towards a reconnection to nature (Rifkin, 2011). The dynamic between technology and nature, or their possible cooperation, for example as LT or 'mid-tech', is becoming increasingly important as the last centuries have been dominated by the increasing use of technology. At the same time, this trend has led to significant environmental impacts. LT aims to conceptualise the balance between reducing technology and questioning needs.
This article has examined different types of scenarios that are presented as a useful method for incorporating future uncertainty when addressing LT: archetypal scenarios and established institutional scenarios. The analysis of the literature showed that the existing scenarios rather refer to LT as a concept making it possible to compare the use of a lot of technology with little technology, or lower economic development. Consequently, we identified an interest in using the LT concept in a more assertive way and crossing it with different uncertainties that appeared throughout the conducted analyses. The most relevant aspects identified are:

- Local/bottom-up vs. global/top-down – Where are decisions made and resources distributed?
- High vs Low GDP – Is LT a necessity or a choice?
- Old vs. modern – Is LT a continuation of traditional practices or a new independent movement?
- Solidarity/community versus anonymity – Is LT linked to forced or independent social dynamics?

Additionally, we noted a lacking link to planetary boundaries (Steffen et al., 2015) which could provide a more structured framework across LT axes. Building on the identified lack of diverse LT scenarios, we suggest developing sets of scenarios that consider LT as a pervasive trend and then examining different variations or blending LT/HT as a critical uncertainty on one axis with one of the other dimensions mentioned previously. For example, pairing LT with high or low GDP and seeing how each combination might translate into society and the economy. Furthermore, an analysis of four different LT scenarios can be relevant as well. Mostly in the context of normative sustainability transitions attempting to reach the goals of the Paris agreement or net zero by 2050, it is common to have multiple scenarios that all achieve the predefined objective (cf. Chen et al., 2021 [IPCC]; IEA, 2022). Table 5 shows an example created by the authors for illustrative purposes. All of the scenarios maintain the LT

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idea and achieve net zero emissions by 2050 via different combinations of two other critical uncertainties, namely solidarity vs. anonymity and bottom-up vs. top-down implementations. Regardless of its exact implementation, the performed analysis shows that the LT concept can bring an interesting dimension to scenario-based approaches for more sustainable development that has so far been underexploited.

Table 5. Example of scenario sets with variations of low-tech

	Bottom-up implementation	**Top-down implementation**
Solidarity	*This scenario focuses on local action, initiated and driven by the civil society. The solidarity element includes activities such as non-monetary sharing practices and influencing national policy via local initiatives.*	*In the second scenarios, sustainable and low-tech development is achieved via solidarity. However, compared to the previous, this is enabled through top-down initiatives, creating a welcoming context for such practices. Examples of such activities can be commonly found in Singapore.*
Anonymity	*In the third scenario, people try to reduce their own negative impacts, optimise resources, self-sustaining, etc. but do so on their own initiative and independently without high reliance on their local network. These scenarios might be more adequate for high-density and already predominantly anonymous contexts in highly urbanised areas.*	*People's activities are highly regulated from the government and translate mostly to what can be done in the own household. These might include financial incentives or restrictions on resource use (e.g., water, electricity) or encouraging schemes on using technological devices longer or returning them to central reuse or recycling facilities. However, the transition happens on a fully individual, anonymous level.*

6. Conclusions and future work

Starting from the general question *'to what extent is the LT concept integrated into scenario-based foresight?'*, we proposed to examine the potential contribution benefit of LT for constructing scenarios. The question of technological development (rapid or decelerating) is often at the heart of the construction of future scenarios in scientific literature. Beyond that, the appropriation of technologies by people and user-friendliness appears to be little addressed. The recent institutional scenarios that were identified seem to embrace the concept of LT more, in particular the 'Frugal Generation' scenario developed by Ademe (2021). Furthermore, the use of scenario archetypes is useful for the democratisation of prospective studies, provided that these archetypes sufficiently break with consumerist models and integrate crisis phenomena. The choice of recent archetypes like those developed by Fergnani and Song (2020), more radical and transformative than those of Dator (2017), is of interest in this framework. The use of archetypes in design, however, requires being able to adapt them to the study area and localise them in the case of a city or a region for example. This remains a strong issue associated with the use of future scenarios (Gall et al., 2023).

Considering for instance the proposed approach for strategic risk management within the sustainability transition (Schulte, Villamil and Hallstedt, 2020), our contribution on LT scenarios is mostly centred on Vision and Forecasting stages. This does not offset the importance of backcasting in the creation of such scenarios, i.e. not only considering what might be happening, but also what must be happening in order to achieve sustainability in the long term (De Smedt, Borch, and Fuller, 2013).

In addition to the potentials identified in the existing literature, our analysis results in two future research perspectives. First, the search for a combination of scenarios and LT did not provide an example applied to the urban context. The fact that locality is an important factor in LT scenarios and concepts, and that urban areas are both the origin of the majority of global pollution and the habitat of most of the world's population, would invite a more detailed exploration of LT scenarios in this localised context. Second, the recent awareness of planetary boundaries present in the LT approach does not yet appear in existing future scenarios. We postulate that LT thinking associated with planetary boundaries would be an interesting proxy towards more transformational scenarios, despite of the implementation challenge it

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bears to downscale from global to regional or company scale, but in accordance with an absolute sustainability spirit.

This research has some limitations. First, few institutional scenarios were examined, and these are mainly extracted from a French context which is a limitation to external validity. The analysis could be easily extended to institutional scenarios from other countries. Second, we conducted a semantic-based qualitative analysis and highlight that other wording choice could lead to a difference in the detailed outcomes. Lastly, the actual classification of low or high-tech innovations is debatable and prone to change as time goes by. In Bauwens et al. (2020), low-tech innovations are either 1) non-R&D intensive, or in the paper scope 2) entail behaviour changes, which can nevertheless be facilitated by high-tech solutions like digital platforms.

In conclusion, we argue that to project ourselves into multiple futures by integrating the LT concept, we must go beyond the development of a single LT scenario. The challenge is to construct more sets of future scenarios which would tend to consider LT as a trend associated with other uncertainties as exemplified in the discussion section. To do so, we presented some avenues for developing such scenarios, relying on archetypes, institutional scenarios, and common critical uncertainties. The paper brings elements to complement futures literacy, deemed important for researchers (notably in engineering design) as well as private sector and policy decision-makers (Smedt, Borch, and Fuller, 2013). The wider uptake of LT concepts in foresight-based approaches can contribute to the design of more sustainable solutions and the net zero and sustainability transition needed at large scale, systemic level, and long term (Garduño García and Gaziulusoy, 2021).

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