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Review Article

Tomorrow's Buildings: What Are the Occupational Health and Safety Issues?

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Climate change, the need to save raw materials and energy, the development of information and communication technologies that will enable the automation of construction sites, but also change the administrative management of these sites, etc. All these changes are opportunities to improve working conditions in a sector which, even if significant progress has been made in recent decades, is still too often lagging behind when it comes to occupational risk prevention. As part of an overall forward-looking analysis of changes in the building industry in France over the next 30 years, specific work has been devoted to the question of working conditions and the possibilities for improving them (or avoiding their deterioration). As techniques and professions are bound to evolve, what are the main levers we can use to ensure safer, more fulfilling working conditions?

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1. Introduction

The question of tomorrow's buildings (whether for living or working), their design, construction or renovation, fitting out, maintenance, and upkeep, is of particular importance at a time when the evolution of many elements of the context will impose significant changes on our lifestyles:

- The current scarcity of housing, particularly affordable housing, which makes it difficult for many people to rent or own[1][2],
- Climate change, the effects of which are increasingly being felt, with the possibility of a rise in temperatures in a context of an explosion in the number of natural disasters, which will imply a change in consumption patterns and, in particular, the need for more energy-efficient housing[3][4],
- Technological changes that influence construction itself[5][6], but also through the development of information and communication technologies (ICTs) on the use and management of buildings[7][8].

More cyclically, the Covid-19 health crisis has had the effect of modifying the living and working conditions of many people: acceleration of technological change[9], development of teleworking in flats that are not necessarily adapted, expansion of home delivery with the resulting appearance of dark kitchens and dark stores near places of consumption, particularly on the outskirts of town centres in premises that should be adapted to their new use, etc.

Noting that the coming decades will see major changes, the CSTB (Centre scientifique et technique du bâtiment - Scientific and Technical Center for Building) and the Ademe (Agence de l'environnement et de la maîtrise de l'énergie - Environment and Energy Management Agency) decided to initiate a foresight process entitled "Imagining tomorrow's buildings together"[10]. The aim was to develop common tools for all professionals involved in construction activities, which could be used for forward thinking. The underlying logic, usual in foresight, is to anticipate future developments in order to be better prepared for them. The time horizon chosen for this prospective work is 2050.

Recent prospective literature on this subject is not very abundant. It also has the particularity of often being devoted to one (generally rather technical) part of the problem: the possibilities of reusing materials from demolition or deconstruction as close as possible to the sources[11], the logistical services that the construction industry will need in the decades to come[12], or the possibilities of associating the stakeholders in this industry in a logic of standardisation of demand in order to reduce the prices of materials and services[13]. A study carried out in the United Kingdom is closer to the French study presented in this article, but it is an introductory chapter to a book devoted to the future evolution of various technical aspects similar to those set out in references 11 to 13[14].

To return to the study initiated by the CSTB and the Ademe, the INRS (Institut national de recherche et de sécurité – the referent body for occupational risk prevention in France) was asked to participate in this project because of its work in the field of occupational risk prevention. This institute has also had good expertise in foresight for about ten years and has produced work in this field on several themes that could contribute to the reflection on the construction of tomorrow. We can cite studies on what France will produce in 2040[15], the use of ICTs[16], the circular economy[17], and the organisational changes in work that could result from the Covid-19 health crisis[18].

Based on some of the extensive material collected during this Ademe - CSTB study (referred to as Study A in the remainder of this article), INRS conducted a second study specific to occupational health and safety issues (referred to as Study B), entitled "Tomorrow's buildings, what are the occupational health and safety issues?", the results of which are presented in this article.

The study was conducted within a French framework with French experts. However, whatever the specific features of French construction techniques, it does not seem unreasonable to consider that much of the data produced in this study can also be applied on a European scale. And more cautiously, given the different approaches to labour legislation and occupational risk prevention, the results of this study may well inspire researchers working on other continents.

2. Material and methods

Although this article is mainly devoted to Study B, given that much of the initial material comes from Study A, the methodology used for both studies will be described in this section, more succinctly for the initial study.

2.1. Study A

A project group of 17 people was formed. Their specialities were very diverse: architects, urban planners, building engineers, economists, anthropologists, energy specialists, etc. They came from a variety of companies involved in the project: construction itself, design offices, urban planning agencies, universities, etc. Their work lasted for a year and a half in 2020 and 2021 (16 sessions), mostly by videoconference, given the Covid-19 pandemic.

The working method used was the construction of contrasting scenarios with the following main objectives[19]:

- to identify the factors to be studied as a priority (key variables), by linking, through the most exhaustive global explanatory analysis possible, the variables characterising the system under study the variables characterising the system under study;
- to determine, in particular on the basis of the key variables, the fundamental actors, their strategies and the means they have at their disposal to carry out their projects projects;
- to describe, in the form of scenarios, the evolution of the system studied, taking into account the most likely evolution of the key variables, and based on sets of hypotheses on the behaviour of the actors.

The work was carried out in three stages:

- The first was devoted to identifying the key factors that will structure the evolution of building and real estate in France between now and 2050, which were classified into four families: factors related to the general context, factors related to demand, factors related to supply, and factors related to public policies.
- For each of these 22 key factors, a clarification was made of what they cover, and their evolution over the last thirty years was reconstructed (i.e. the period of time for which we are projecting forward during this exercise) during the second stage. On this basis, a reflection was undertaken on the possible evolutions over the next thirty years, based on the major trends but also on weak signals or by

envisaging possible ruptures: this led to the drafting of a few hypotheses for each key factor, summarising the main elements likely to influence the future of this factor.
- In the third stage, the hypotheses of all the key factors were combined, according to the very simplified scheme in Figure 1, in order to create scenarios to illustrate the possible futures. Given the large number of key factors and therefore the number of possible combinations of hypotheses, the working group proceeded in successive iterations, first within each family of factors and then by combining these results. In the end, the group came up with four so-called contrasted scenarios, describing very different possible futures.

2.2. Study B

As mentioned above, this study aims to extend Study A by focusing on occupational health and safety issues.

For this purpose, a specific project group of 11 people was formed, two of whom had participated in Study A: a futurist from a specialised foresight organisation and another from INRS. The other members were mainly building specialists with OHS expertise and OHS specialists often with a specialisation in the building sector.

As in Study A, the method of contrasting scenarios was used. The logic of filiation with this study (as well as a logic of economy) led to the inclusion in Study B of the seven variables that were most relevant for further exploration of occupational health and safety issues:

- Occupancy of non-residential buildings (variable 8 in Study A)
- Technical policy (variable 22)
- Obsolescence management (variable 15)
- Quality of use of buildings (variable 16)
- Organisation of the construction-renovation sector (variable 14)
- Materials, products and equipment (variable 13)
- The building workforce (variable 12)

In a conventional way, the combination of the three or four hypotheses generated in Study A for each variable resulted in the creation of four scenarios (different from those in Study A). The method used is summarised in Figure 1.

Variable #1	**Hypothesis #1**	***Hypothesis** #2*	Hypothesis #3	Hypothesis #4
Variable #2	***Hypothesis #1***	**Hypothesis #2**	Hypothesis #3	
Variable #3	Hypothesis #1	***Hypothesis** #2*	**Hypothesis #3**	
Variable #4	***Hypothesis #1***	Hypothesis #2	Hypothesis #3	**Hypothesis #4**

Scenario #1 results from the combination of **hypothesis #1** of variable #1 with **hypothesis #2** of variable #2, etc.

Scenario** #2* results from the combination of ***hypothesis** #2* of variable #1 with ***hypothesis #1 of variable #2, etc.

Etc.

Figure 1 - Example of the creation of scenarios based on the hypotheses of the different variables identified

These hypotheses will not be detailed in this article; only a short summary will be provided in the Results section: the interested reader is referred to the synthesis of this exercise B[20]. A summary of the four scenarios is also presented in the Results section.

On the basis of the situations illustrated in these scenarios, the group reflected on the future transformations that could have the most significant consequences in terms of occupational risks and prevention policies. The horizon chosen was 2050, as in the initial CSTB and Ademe exercise. Three main drivers of transformation were thus identified, and for each of them, the two main changes to which they could lead in building activities. These elements will be presented in the Results section.

Lastly, focus was placed on specific themes that already present strong challenges for the prevention of occupational risks and which future developments in the organisation of worksites or construction techniques could make crucial.

The choice of the drivers of transformation, the main changes, and the high-stakes themes was made during plenary sessions of the project group. Each of the selected elements was then investigated either by a member of the group individually or by small groups of two to four people. The results of this work were then presented to the project group, which amended and adopted them.

3. Results

3.1. Scenarios

The results of Study A[5] are not presented in this study: it has only been referred to and its methodology described because this study provided a significant part of the basic material from which Study B was constructed.

Table I summarises the hypotheses for each of the seven variables used to construct the four scenarios in Study B.

Variables #	Hypotheses
8 - Occupancy of non-residential buildings	1. Stagnation - Businesses are changing and space is changing with them, but business sectors are keeping space occupied constant 2. Tertiary crisis - The explosion of teleworking and e-commerce is driving down demand for office and retail space 3. New dynamics - The explosion of teleworking and e-commerce is causing demand for office and retail space to fall and be reallocated to new activities
12 - The building workforce	1. The sector is becoming attractive - Major training efforts in a context of technical progress and career prospects 2. Labour shortage - Companies are compensating for this by relocating industries, formalising the craft industry, developing seconded labour, illegal work and "do it yourself". 3. Polarisation of the labour market - This is reflected in the disappearance of medium-skilled jobs
13 - Materials, products and equipment	1. Frugality - Increasing use of biobased, geobased and local products. Economical and relevant use of traditional products 2. Circular economy - Reduction of final waste, major work on the design of reusable and recyclable products 3. Technicisation - Technological innovation: super-insulating, self-cleaning, variable transparency, self-repairing products... Construction products and equipment are becoming digital and connected
14 - Organisation of the construction-renovation sector	1. Stagnant productivity - Sterile competition between players even in areas of common interest such as BIM adoption 2. Collective improvement - Awareness of the ability to collectively increase efficiency through better coordination 3. Empowerment of coordinators - They take the role of conductor ensuring collective coordination and capturing the added value 4. Industrialisation - Significant part of the added value transferred from construction site to factory. Reduced construction time
15 - Obsolescence management	1. Rapid renovation - Massification of renovation of existing buildings rather than new construction 2. Slow renovation - The obsolescence of the building stock is growing with a mismatch with demand in a context where the shares of new and renovation remain constant 3. Redesigning the city - The share of new buildings in the market is growing in a context where environmental performance is becoming an important criterion
16 - Quality of use of buildings	1. Furniture and equipment - The premises are standardised and the occupants adapt them to their needs through their equipment 2. Photos and green plants - High mobility of occupants in standardised premises which they move frequently 3. Walls adapt to demand - Flexibility of building and spaces. Design methods are revolutionised
22 - Technical policy	1. Patchwork of technical rules - Multiplication of inconsistent rules. Poor management of construction and renovation. 2. Quality of new and renovation - Shared framework accepted by actors. Objectives achieved in terms of sustainable development

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Variables #	Hypotheses
	3. Quality of the new - Good adequacy of the new. Renovations are inconclusive except for large projects

Table I. Variables used in study B and corresponding hypotheses

3.1.1. Scenario 1: Hard to do everything

A gap is created between customer demand and the construction industry's supply. The latter remains highly standardised in order to reduce costs. It is constrained by factors such as cost control, compliance with regulations, the duration of building sites, etc. However, at the same time, productivity is stagnating in a context where the largest companies are trying to make production more technical, where environmental constraints are increasing, and where staff recruitment difficulties are high. Expedients are used which tend to increase disorder rather than solve the problems: the use of the principles of the gig economy to contractualise the work of subcontractors (especially craftsmen), the use of foreign workers on secondment or even in an irregular situation, etc.

3.1.2. Scenario 2: Sustainability companions

The ecological transition and the need for energy renovation of many buildings, the evolution of working methods with in particular the development of remote working, and a strong investment by the building profession in technological developments (new materials, circular economy, bio-sourced materials) are giving construction a central place in society's expectations. This is reflected in particular by a renewed interest among the workforce. Small structures (often built on a cooperative model) are appearing which develop a targeted offer, often in cooperation with large companies. All these changes are made possible and accompanied by a strong political will.

3.1.3. Scenario 3: Industrialisation and circular economy

The increase in climate change highlights the inadequacy of the available building stock. Rather than undertaking very costly and not necessarily very efficient renovations, priority is given to the construction of new buildings. In addition, the latter are better suited to the evolution of living and working conditions. This construction policy is marked by the development of industrialisation. However, it soon became apparent that the natural resources available were limited. It encourages a circular economy, which applies more to the construction of new buildings than to the recycling of old ones: from now on, every product is designed to be dismantled, reused, or recycled later. A polarisation of the labour market emerges with low-value deconstruction tasks and increasingly technical jobs in construction.

3.1.4. Scenario 4: Construction on digital platforms

The population's appetite for new technologies used in buildings (home automation, but also in the professional context) is growing. The niche is occupied by digital companies with expertise in digital marketing that have taken over construction, renovation, and interior design companies. The business model is also changing: these companies call on construction companies to provide the building envelope and then offer turnkey solutions for "furniture and equipment," "ambience," or "usage services." All this results in a strong development of innovation in all areas related to construction. Jobs in design are developing, while those in construction proper are becoming very routine and highly prescribed. Employment is often organised according to the principles of the gig economy, with a strong reliance on self-employed and precarious workers.

3.2. Drivers of transformation and main changes

Three parameters are expected to have a strong influence on the evolution of construction activities and occupational risks over the coming decades: digitalisation, environmental transition, and industrialisation of the sector.

3.2.1. Digitalisation

In view of the development of new technologies, few sectors of activity contributing to the construction activity are likely not to be affected. The project group has chosen to deal with two particular issues: BIM (Building Information Modeling) and the development of the platform economy.

a. BIM

This technique allows information to be shared between all the parties involved in a project. It consists of the use of a shared digital representation of a built asset to facilitate the design, construction, and operation processes so as to provide a reliable basis for decision-making. It is a useful tool, if not sufficient, to ensure the coordination of the actors intervening on a building site: the co-activity of different trades often results in increased professional risks. As such, it can be used to organise prevention upstream during the site preparation phase, to update procedures during the site, or to identify new risks. It applies equally to construction, deconstruction, and demolition activities.

However, the capabilities of BIM should not be exaggerated: it does not exempt those responsible for occupational risk prevention from asking the right questions at the right time. It must be informed in a relevant and regular manner to avoid decisions being taken on the wrong basis. This is why one of the essential challenges in the years and decades to come is to ensure that all enterprises acquire a good command of the use of this tool.

b. Platform economy and new consumption patterns

After investing in passenger transport (Uber) or food delivery (Deliveroo), digital platforms are starting to develop in sectors such as personal services: their objective remains the same, to bring suppliers and customers together. In the field of construction, there are also platforms, mainly in the finishing sector, which put craftsmen in contact with private individuals. This often leads to more standardised services and allows the customer to benefit from related services such as insurance or the guarantee of subsequent maintenance. Materials dealers have also set up platforms to put individuals in touch with 'experienced handymen' who have adopted a self-employed status and who can carry out building work.

It is possible, indeed likely, that these activities will expand in the future. It is not possible to predict today what the consequences will be in terms of health and safety at work. Platforms can impose strict rules, promote (or impose) the use of high-performance safety tools by negotiating their prices with suppliers (grouped purchases), and avoid low-end services. On the other hand, this development can be anarchic, resulting in the hiring of insufficiently trained people or people who neglect safety instructions, which can cause problems of coactivity. The traceability of this work may be poor and subsequently generate incidents or accidents.

It is clear that all these changes could have a significant influence on the progress of construction sites in the years to come. It will therefore be necessary to be particularly vigilant, all the more so as the current regulations may prove to be unsuited to the organisational changes to come, linked to the development of the platform economy and the gig economy.

3.2.2. Environmental transition

The building sector is particularly concerned by developments linked to the environmental transition: lowering the energy consumption of buildings, reducing carbon dioxide emissions, adapting to increasingly frequent climatic hazards, limiting the consumption of building materials (particularly sand), reducing the quantity of final waste, stopping the artificialisation of land, etc.

The choice has been made to deal here with energy-efficiency renovation and the circular economy.

a. Energy-efficiency renovation policies

The market is currently very concentrated on the renovation of social housing. It is divided between integrated renovation operations in which all the elements of the dwelling will be modernised and operations carried out over several years during which the elements will be changed or improved little by little. As mentioned above, integrated operations are the most worrying in terms of occupational health and safety, as they often involve co-activity.

The main issue is the likely accelerated development of these operations in the coming years. They will also affect private housing on a larger scale. It will therefore be necessary to have a numerically important workforce. The question of training is crucial, since we know that it is through training that positive attitudes to occupational risk prevention can be acquired. Moreover, this can happen in a context of easy money, where the volume of work is high and the subsidies for carrying it out are significant, a context which is not conducive to the quality of the work or to good occupational risk prevention.

b. The circular economy

Although the recycling of concrete and concrete sludge is gradually becoming common practice, encouraged by regulations, the practice of reusing equipment (from door handles to windows to ceramic equipment) is still marginal. In addition to the lack of habit of this practice, the elements currently in existence were not designed for reuse, and dismantling operations often result in breakage. In the coming decades, the practice will probably become more widespread. This evolution towards reusable products will have to be accompanied by a reflection on working conditions in order to avoid the development of musculoskeletal disorders (MSD) of the upper limbs and back pain, resulting from excessive and/or repetitive efforts or the adoption of awkward postures.

Similarly, a certain degree of traceability must be ensured so that objects or materials are not reused beyond a reasonable lifespan. The aim is to avoid accidents during dismantling or reassembly operations, or degradation of materials that could lead to worker exposure (or enrichment in toxic compounds).

3.2.3. Industrialisation of the sector

Construction processes are increasingly similar to those of industry. This issue is addressed through two phenomena: the development of off-site construction and the emergence of robotisation.

a. Development of off-site construction

The construction of prefabricated elements which will then be assembled on the building sites, or even of more complete modular elements, is a phenomenon which is developing strongly in the construction sector. In terms of occupational risk prevention, this is generally a step forward, since working conditions in the workshop are easier to control and improve. In the workshops, it is easier to invest in fixed equipment that facilitates handling, reduces the physical load, and avoids painful postures. On construction sites, the handling of prefabricated elements is mechanised. If it is well managed, occupational risks are better controlled.

Recruitment can be facilitated, as a large part of the workforce works in a fixed location without being subjected to difficult weather conditions. The unfavourable counterpart in terms of occupational risks is the one that has been observed for several decades in industry: the risks of deskilling, excessive constraints due to compliance with procedures that are too strict and out of step with the actual work, and excessive intensification of the workload.

b. Emergence of robotisation

Construction companies have been testing different models of exoskeletons for several years: the issue of carrying loads is indeed recurrent in these activities, and the aim is to relieve the operators. The results are not always as expected, since the principle of existing exoskeletons is to transfer the pressure exerted on the lumbar vertebrae to another part of the body. The development of active exoskeletons with motorisation to neutralise this pressure is interesting: we can hope that the questions of weight and cost of these devices will find a solution in the years or decades to come. Particular attention will have to be paid to the conditions of use of this equipment: control of the body's reaction in the medium term, risk of task intensification, etc.

The robotisation of tasks is also possible: it is likely to be more easily applicable in the context of the industrialisation of production (prefabricated or modular elements) than on the building sites themselves.

3.3. Four high-stake themes: challenges for prevention today and tomorrow

3.3.1. Coordination between the actors in the construction sector

Several times in this article, reference has been made to the question of coordination of activities between the various companies working on a site. In terms of occupational risk prevention, France has specific regulations transposing the eighth individual directive 92/57 concerning temporary and mobile construction sites. This text has been the subject of much criticism over time, particularly with regard to the coordinator's function, which consists in particular of helping companies to manage the problems posed by coactivity.

The changes mentioned in this article, such as BIM, but also new technologies such as "video visit" tools or drones, could significantly change the management of the various coordination and prevention plans and, in particular, the coordinator's function mentioned above. A fair balance will have to be found between what technology allows and the need to maintain human contact, which is often necessary to update and resolve specific situations at the limits of what is possible.

3.3.2. Subsequent interventions

The sometimes haphazard management of compulsory documents aimed at gathering all the data likely to facilitate the prevention of occupational risks during subsequent interventions on the building is a real problem: the resulting insufficient traceability does not always make it possible to put in place the necessary provisions for workers brought in to intervene in the context of the maintenance and upkeep of the building. BIM can help to improve these records. However, it will only be fully effective if measures are taken at the design stage to incorporate technical rules to facilitate the maintenance and deconstruction of the building's components.

The servitization model, mentioned in scenario 4 in particular, can also allow progress: maintenance and upkeep will be better integrated into the design to control costs. However, there is no technical obstacle for these operations not to be considered as important as they should be in other cases.

3.3.3. Re-use of buildings for new purposes

Industrial workshops can be transformed into offices, an architecturally interesting building can be enhanced, car parks can be given a new function as logistics warehouses, a derelict building can be transformed into a third place, etc. The limitations inherent in the architecture and type of construction of the original building must not constitute obstacles to a redevelopment that allows workers to carry out their activity under good conditions. These include ventilation of the premises, access to natural light, and management of traffic flows, in addition, of course, to what is specific to each activity.

3.3.4. Taking climate change into account in occupational risk prevention for construction workers

When climatologists predict an average rise in temperature of several degrees in the coming decades, this cannot remain without consequences for the activity of construction workers and the occupational risks arising from it: a large part of their activity takes place outdoors with high exposure to weather conditions. Admittedly, the trend towards increasing prefabrication will probably reduce the amount of time spent outdoors, but organisational measures will have to be taken, such as changes to working hours or the installation of devices to provide protection from the sun. We will also have to take into account the risks associated with the increased frequency of extreme and sudden phenomena such as storms and floods. More than ever, construction activities will be dependent on the climate.

4. Discussion

On the basis of all the material presented in this article (scenarios, drivers of transformation, main changes, etc.), a reflection was carried out on the possible evolutions of a few types of occupational risks (among the most common and the most important in terms of consequences) as well as on the possible evolutions of the corresponding prevention policies. This reflection, carried out by the entire project group, resulted in Table II.

	Possible risk reduction factors	Possible risk increase factors	Possible innovations in prevention
Musculoskeletal disorders	Industrialisation and prefabrication can contribute to shorter construction sites, better-controlled work situations, and more mechanised handling	Industrialisation and prefabrication can also contribute to the intensification of work and the repetitiveness of gestures. In this context, finishing may involve more repetitive manual tasks under time pressure Careful cleaning operations aimed at reusing elements (circular economy) require more manual intervention	Automation of certain tasks in the prefabrication workshops Progress in on-site robotisation, with in particular the use of collaborative robotics
Falling hazards	New works: BIM enables better integration of collective protection into the processes during the various phases of the worksites Renovation works: well-designed and well-organised processes allow the pooling of fall prevention resources. BIM can also be a useful tool	The time constraint can become a negative element in the management of construction sites: the capacity to manage hazards in the context of increasingly precisely planned construction sites becomes an important element in avoiding accidents. On renovation sites, it is necessary to avoid fragmented and uncoordinated interventions which can increase the number of accidents, in particular falls.	Systematic integration of collective protection into the process via BIM. Collective protection can be integrated into prefabricated elements In all sectors: the use of drones and robots can expose workers to work at heights
Chemical risks	The prevention of occupational risks is facilitated by prefabrication in the factory (pollutant collection devices in the workshops)	Demolition and deconstruction operations can expose people to old pollutants, which are not always identified. The recycling phases of materials may present particular risks of exposure The toxicological properties of the new materials used may be insufficiently documented	Mobile clearance units or the use of collaborative robotics can limit exposure risks on construction or renovation sites.
Psychosocial risks	The use of digital tools can make it possible to better plan construction or renovation sites and limit unforeseen events, improve the organisation of work, reduce uncertainty, and lighten the mental load. The construction of prefabricated elements allows for better control of processes and risks, improved medical monitoring, and the preservation of work collectives that promote social support, mutual aid, sharing of safety know-how, etc.	Digital tools can increase cognitive load, translate into last-minute changes that are difficult to manage, increase prescription, and reduce room for manoeuvre Prefabrication can alter the meaning of work by distancing the operator from the site Large renovation sites are conducive to the development of situations of external violence	A truly collaborative BIM can enable good planning and information sharing for the benefit of OSH

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Table II. Possible changes in the most common risks and possible changes in the corresponding prevention policies in the coming decades

The problem of work-related accidents and illnesses has long existed in the construction industry, where statistics are generally worse than in other sectors, regardless of the country's level of economic development. The link is generally made with a lack of training for the least qualified workers, whether in developed countries[21] or in those less economically advanced[22]. This issue of training could well be one of the essential parameters for the successful development of construction activities in the years to come. As we have seen, most of the scenarios bet on the development of activities using technology-based construction techniques. This will require a workforce at all levels of the company capable of using advanced techniques.

This training must also include a strong focus on the prevention of occupational hazards: learning the technique must be accompanied by learning how to use it safely, in order to avoid accidents or exposure (respiratory, cutaneous) to a toxic product. To achieve this, sufficient time must be allocated to training workers: studies devoted to this question have shown the temptation to reduce, for cost reasons, the volume of theoretical training in schools in favor of work placements, so that young people in technical education are more quickly "profitable" for companies[23]. This seems a poor choice in the short term, since the occupational risk prevention gesture that we wish to attach to the professional gesture may not be acquired for lack of time to learn it during the young worker's training. And in the longer term, it will be more difficult to upgrade workers' skills if they do not have sufficient initial theoretical knowledge, a fortiori in activities which everyone agrees will increasingly involve advanced technologies.

A second obstacle to the technological development highlighted in this prospective study is the issue of subcontracting. Faced with the economic imperatives of profitability and time constraints on construction sites (sometimes requiring increased staff resources over certain periods), many companies in the construction sector turn to subcontractors. Many of these companies are of a high standard, sometimes even more competent in certain sectors than those who subcontract work to them. Others, on the other hand, are primarily labour companies, with staff whose technical skills remain low. The latter are also companies with insufficient expertise in occupational risk prevention. Studies have shown that work-related accidents are more frequent in these companies, in industrial activities[24] or in construction[25]. These safety problems may be compounded by technical difficulties, which, as previously, are partly linked to training issues. Clearly, great attention will also have to be paid to the question of interfaces between prime contractors and subcontractors, in a context where technological issues will become increasingly important[26].

Finally, the developments imagined in the various scenarios could suffer from crisis situations: we're thinking in particular of the rise of climate scepticism in a number of countries, linked in particular to the cost of paying for the ecological transition[27][28]. The costs involved (not just in the construction industry) and the misinformation distilled by certain pressure groups, for whom the paradigm shift (particularly in energy) could represent a loss of earnings, are fuelling frustration among some citizens. This is taking place against a backdrop where housing difficulties have been rising sharply for several years: demand is structurally stronger than housing starts or renovations, and purchase or rental prices are rising faster than the resources of most potential buyers or tenants. In the same way that public authorities around the world have backed away from targets set to mitigate the consequences of climate change, we could see the virtuous principles laid down for the building industry being called into question. Short-termist solutions could be implemented to provide cheaper and more rapidly available housing. In addition to the environmental setback, we could be faced with the adoption of construction working methods that take less account of workers' health and safety in the short and medium term.

5. Conclusion

In this exercise, as in most foresight exercises carried out within our institute, the aim is to propose narratives that enable us to project ourselves into possible futures and to highlight issues that can stimulate reflection and debate on potential consequences in the field of

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occupational risk prevention. The aim is to raise the awareness of players (principals, designers, construction companies, social partners, consultancy, advisory and inspection bodies, etc.) so that they use the data we provide for their strategic questioning. The objective will be achieved if cross-fertilization of OHS awareness results.

The scale of the changes to come in the construction industry, and the diversity of the forces driving them, call for dialogue between players to ensure that the priorities of some do not generate constraints that are detrimental to others, with deleterious short- or long-term effects on workers' health. The digitization of techniques, the ecological transition, and the industrialization of construction all offer potential opportunities for improving working conditions. The usefulness of dialogue must be borne in mind by all those involved in the industry when making decisions: their impact on occupational risk prevention must be constantly assessed. The aim of foresight is to help all these players to engage in forward-thinking and make it sustainable.

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