Embedding Resilience in the Built Environment Using the EU Taxonomy

Edited by Elzbieta Rynska

First published 2025

ISBN: 978-1-032-86809-7 (hbk)
ISBN: 978-1-032-87889-8 (pbk)
ISBN: 978-1-003-53519-5 (ebk)

Chapter 1

Introduction to European Union Taxonomy

Elzbieta Rynska

DOI: 10.1201/9781003535195-1

Routledge
Taylor & Francis Group
LONDON AND NEW YORK

1 Introduction to European Union Taxonomy

Elzbieta Rynska

1.1 Background

The absence of regulations defining which investments are environmentally sustainable has led to a problem known as pseudo-green branding (i.e. the unjustified declaration by some stakeholders that their activities are environmentally friendly when there was no basis for such claims). The European Union (EU) Taxonomy aims to address this problem by creating harmonised European standards. Until the appearance of the Taxonomy, there were no clear, uniform criteria to assess what economic activity could be considered sustainable. The Taxonomy is a response to this problem. It provides a classification system for environmentally sustainable economic activities. It is a tool to create a common language for identifying environmentally sustainable activities and financial instruments in the real estate market.

Taxonomy is the colloquial name of a new act of the EU (i.e. Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020), establishing a framework to facilitate sustainable investment. The new rules aim to increase the level of environmental protection by redirecting capital from environmentally damaging investments to friendlier alternatives. The Taxonomy does not prohibit investment in environmentally damaging activities but gives an extra preference to green solutions.

EU Sustainable Finance has two pillars: the EU Taxonomy for Sustainable Activities (EC, EU Taxonomy …) and the Corporate Sustainability Reporting Directive (CSRD; EU, Corporate …).

DOI: 10.1201/9781003535195-1

The new regulations modernise and strengthen the rules concerning the social and environmental information that companies are required to report. A broader set of large companies and listed small- and medium-sized enterprises (SMEs) will now be obliged to report on sustainability. Furthermore, some non-EU companies will be required to report if they generate over EUR 150 million in the EU market. In accordance with CSRD, companies are obliged to report in accordance with the European Sustainability Reporting Standards (ESRS). The standards have been developed by the EFRAG (formerly known as the European Financial Reporting Advisory Group), which is an independent body comprising a variety of stakeholders (EurLex. Document 32023R2772).

The provisions of the EU Taxonomy provide a set of technical criteria for assessing which investments, products, or services and costs of a company can be considered environmentally sustainable, and thus which of them are more environmentally sustainable in the long term. This should provide a coherent classification system for environmentally sustainable economic activities.

A so-called brown taxonomy is also part of the plan. This will focus on activities that have a negative impact on the EU's climate targets. Work has also started on a social taxonomy, with the ultimate aim of creating a single taxonomy tool that will fully address the ESG aspects.

In order to enable readers to understand the context of the provisions in question, it is worth recalling the basic issues relating to EU law. The general principles of the functioning of the EU are set out in the Treaties. For example, the Treaty on the Functioning of the European Union (EurLex. Treaty…) sets out:

- In which areas may the EU adopt the rules?
- By the procedure by which the rules are adopted.
- What legal effect shall they have on the undertakings?

Formally, the Taxonomy was adopted in order to create an EU internal market, but not directly for environmental or climate protection. It was adopted as the ordinary legislative procedure in which the Council of the European Union, representing the member states, and the European Parliament, representing EU citizens, gave their consent to its adoption. In practice, however, the Regulation only established a general framework of rules. Many key issues still have to be fine-tuned in delegated acts adopted by the European Commission.

In the past, environmental legislation tended to be adopted in the form of directives that had to be replicated in the laws of the Member States. The Taxonomy was adopted in the form of a regulation, which is directly

applicable. The provisions of the Taxonomy will not be repeated in the laws of individual countries. Thus, the assumption that entrepreneurs know, or will know, the principles of the Regulation and thus have to comply with the obligations stated therein is rather artificial.

The Taxonomy is intended to be a reference point in the search for an answer to the question of whether an activity is environmentally sound, regardless of whether Member State or EU legislation applies in a particular case.

Currently, the Taxonomy covers 13 sectors and more than 100 economic activities. It identifies six environmental goals, which are key to the transition to a sustainable and neutral low-carbon economy. It includes a list of activities that can be considered environmentally sustainable if they meet the technical screening criteria. The taxonomy identifies specific, often challenging environmental indicators and acts as a tool to support investment decisions. Companies with classified environmentally sustainable operations will be in a better economic position because many stakeholders will be interested in green investments. The Taxonomy will also have an indirect impact on leases in the context of changing requirements and expectations of tenants and real estate investors. It will be an effective tool for combating the so-called greenwashing zone, using a set of specific technical criteria for environmentally sustainable operations. Hence, this approach will also have a significant impact on the development of architectural and construction projects, including the selection of buildings and finishing materials.

1.2 Introduction to the contemporary climate crisis

Climate change influences every corner of our globe. Regardless of their cause, they are detrimental to Earth's living species, threaten human existence, are progressive, and affect many issues simultaneously, such as temperature rise, drinking water deficits, flooding of coastal areas, air pollution, ocean salinity, and many others. Some areas are under direct threat from the passage of hurricanes, tsunamis, or fires associated with high temperatures and drought, while in others, the changes are more discrete and, for the time being, affect the population less.

There is ongoing debate among scientists and laypeople alike about the causes of these changes. How much is due to anthropogenic or human-induced factors (mainly relating to population growth and consumption)? And how much is due to the cyclical nature of natural increases and decreases in temperature, solar activity, or changes in the Earth's polarity, axis tilt, and orbit? Advocates of theories that emphasise the role of natural causes usually cite evidence showing a lack of research on Earth's warming and glaciation periods. They also consider the influence of volcanic eruptions or various astronomical factors and emphasise the impossibility of making precise measurements for past phases of our planet's development. Many researchers are trying to find a consensus. One of them is Marc Lynas (Lynas et al., 2021), who after thorough research has written:

> We base our methodology on C13, with some important refinements. We searched the Web of Science for English language 'articles' added between

> the dates of 2012 and November 2020 with the keywords 'climate change', 'global climate change' and 'global warming'. C13 used the latter two phrases but not 'climate change' without the preceding 'global' […] This wider set of search terms yielded a total of 88125 papers, whereas C13 identified a total of 11944 abstracts from papers published over the years 1991 and 2011. […] To further extend our approach for identifying as many sceptical papers as possible within the full dataset, we created an algorithm to identify keywords within the papers rated by C13 as sceptical […] Our finding is that the broadly-defined scientific consensus likely far exceeds 99% regarding the role of anthropogenic GHG emissions in modern climate change, and may even be as high as 99.9%.

Hence, for the vast majority of scientists, the human impact on accelerating climate change is indisputable. The thesis that climate change is caused primarily by human activity is supported by the authors of more than 99.9% of peer-reviewed climate science publications. Such conclusions came, for example, from meta-analyses of more than 88,000 scientific reports from 2012 to 2020 (Clark and Tilman, 2017; Matthews et al., 2018; Markard et al., 2020).

The available evidence indicates that human activity is a significant contributing factor to the current climate crisis. The focus is on the impact of greenhouse gases (GHGs) and atmospheric carbon dioxide emissions resulting from industrialisation and the use of fossil fuels. These emissions have led to notable differences from the conditions observed during the pre-industrial era. The consequences for the planet are wide-ranging. These include the melting of glaciers and the associated rise in the level of the oceans. They also include the discovery of methane deposits, the release of poisonous gases into the atmosphere, and a lowering of oxygen levels in the atmosphere and water. This further influences the extinction of aquatic species and the desertification of previously fertile areas, linking the changes to the extinction of terrestrial species. The human population is facing a range of challenges, including food and water scarcity, inter-group conflicts and social unrest, habitat destruction and migration, pollution-related diseases, and, in the most pessimistic scenarios, the extinction of the human species and the majority of life on Earth. Notwithstanding the evident consequences of warming and in sequence of the planet's contamination, these signals are frequently disregarded by those for whom a changed economic approach would entail reduced profits and greater costs in the economic and industrial sectors.

Anthropogenic climate change is primarily linked to the development of increasingly comfortable human living conditions in industrialised countries and to consumer-driven production. Consumption made its earliest mark in North America (Borowska, 2009). Material goods were available to anyone willing to work reliably and could advance socially through their possession, making the consumerist model particularly attractive. A few decades later, this attitude also developed in Europe.

In 2018, the Intergovernmental Panel on Climate Change (IPCC), the United Nations body for assessing the science related to climate change, produced a Special Report on Global Warming of 1.5°C (IPPC. Global …).

This particular report covers the impacts of global warming of 1.5°C above pre-industrial levels and related global GHG emission pathways. The main emphasis is on human influence as the principal agent of change on the planet, shifting the world out of the Holocene period into a new geological era, often currently named the Anthropocene (Gradstein et al., 2012; Waters et al., 2016). Responding to climate change in these new conditions requires approaches that integrate multiple levels of interconnectivity across the global community. The rise in CO_2 concentration since 2000 is about 20 ppm per decade, which is up to ten times faster than any sustained rise in CO_2 during the past 800,000 years (Bereiter et al., 2015). It was also acknowledged that the last geological epoch with a similar atmospheric CO_2 concentration was the Pliocene, 3.3 to 3.0 Ma (Masson-Delmotte et al., 2013). Since 1970, the global average temperature has been rising at a rate of 1.7°C per century (NOAA, 2016). These global-level rates of human-driven change far exceed the rates of change driven by geophysical or biosphere forces that have altered the Earth system in the past (Foster et al., 2017).

Furthermore, this approach also includes modifications resulting from sudden geophysical occurrences, which do not align with the current rates of anthropogenic change. This report considers potential pathways that could limit the increase in global mean surface temperature (GMST) to 1.5°C above pre-industrial levels, aligning them with the goals of sustainable development and poverty eradication. In addition, other scenarios are considered, namely those where no climate policy is implemented and current development trends in climate policy are allowed to continue. Such benchmarks are employed in the comparison of mitigation, impacts, and adaptation requirements. The implementation of disparate climate policies gives rise to different temperature pathways, which, in turn, cover distinct levels of climate risk and tangible climate impacts with attendant long-term consequences. The term pathway is used in multiple ways in the climate literature. In many instances, it characterises the evolution of assumed scenario features, such as GHG emissions and socio-economic development. The majority of the sources of emissions from human activities cannot be reduced immediately. The future trajectory of emissions and subsequent warming depends on the feasibility of achieving specified rates of emission reduction. The current level and rate of anthropogenic climate change determine both the time remaining before a critical temperature threshold and the time horizon within which the rate of warming must be reduced to avert exceeding that threshold. A society-wide transformation entails sociotechnical transitions and social-ecological resilience (Gillard et al., 2016). Adaptation pathways must accommodate low-emission energy and economic systems. Furthermore, sociotechnical transitions for mitigation involve removing barriers in social and institutional processes that could also benefit adaptation (Geels et al., 2017; Ickowitz et al., 2022).

Adaptation processes can be implemented on a significant scale, potentially leading to the development of novel strategies within a given region or resource

system. Such a transformation can result in a variety of changes (Kates et al., 2012). In anticipation of 1.5°C, the implementation of adaptation policies would necessitate a wide transformation and planning of flexible adaptations. Furthermore, a transparent understanding of the diverse stakeholders involved and the motives underlying their actions would be required. A thorough knowledge of less visible aspects of vulnerability based on the interrelationships between social, cultural, political, and economic factors should also become an integral issue within the presented policies.

The natural consequences of climate change include threats to economic activity. The impact of climate change is especially significant in the context of infrastructure systems and buildings, given their extended lifespans, substantial initial costs, and indispensable role in the proper functioning of our societies and economies.

The vulnerability of buildings and infrastructure to climate change is contingent upon their design, which may lack sufficient storm resistance or be situated in an area prone to flooding or landslides. Such structures may be damaged or rendered unusable due to changing climate conditions or extreme weather events, including rising sea levels, extreme precipitation and flooding, extremely high or low temperatures, intense snowfall, and strong winds. The consequences of climate change for buildings and infrastructure vary from region to region.

The potential impact of climate change on Europe's energy system is already apparent and is projected to increase in the future. It is anticipated that climate change will result in a reduction in heating demand in the northern and northwestern regions of Europe, accompanied by a notable increase in cooling energy demand in the south, but also in the north of the continent. This could potentially lead to further challenges in meeting peak electricity demands during the summer months.

Foreseen increased frequency and intensity of heatwaves will give rise to shifts in energy supply and demand patterns. Higher temperature rises and extensive droughts may result in reduced availability of cooling water for thermal power plants during the summer months, leading to a reduction in the energy supply. Conversely, the demand for air conditioning is expected to increase, further contributing to a potential rise in electricity demand.

Furthermore, the increasing frequency and intensity of extreme weather events will pose a significant risk to the physical energy infrastructure, including overhead transmission and distribution lines, transformers, and substations.

Climate change also introduces uncertainty regarding the types of weather patterns that will prevail in different regions of Europe. In longer time periods, this will have a direct negative impact on renewable energy production. For example, there may be less solar or wind energy available in regions that are typically sunnier or windy or more heat waves and droughts affecting crops grown for biomass energy production.

Climate change presents a significant threat to businesses on a global scale, affecting the entire planet. However, it is evident that some enterprises are more vulnerable than others. It is anticipated that the effects of climate change will have a particularly adverse impact on SMEs. This is expected to result in a range of

consequences, including disruption to business operations, disruption to supply chains and infrastructure, damage to property, and increased maintenance and material costs, leading to higher prices. Nevertheless, climate action presents numerous potential routes for business development, offering opportunities to design and offer products and services that can contribute to both the reduction of emissions and the capacity of organisations to adapt to a changing climate.

When considering the construction sector, regardless of the emphasis placed on energy efficiency, other changes are also involved. This is the consequence of the changing climate parameters, reduced access to a variety of building and finishing materials, and the requirement to change building material sources from raw to recycled and/or circular, often biodegradable and bio-based, with biophilic characteristics.

1.3 Existing and future regulations

It is estimated that buildings within the EU account for approximately 36% of total energy consumption across all sectors, including industry and transport. Up to 80% of this demand is accounted for by energy used for heating, cooling, and domestic hot water. Eurostat data indicate that approximately 35% of buildings in the EU were constructed over 50 years ago, with only 1% undergoing professional renovation annually (annual weighted renovation rate). While approximately 11% of buildings undergo partial renovation, this does not necessarily indicate an improvement in their energy efficiency. It can be reasonably deduced that approximately three-quarters of buildings are not energy-efficient (Eurostat, 2024).

The subject of energy conservation in buildings and the reduction of their environmental impact has been under discussion for a number of years. The initial legislative measure in this regard was introduced at the conclusion of December 2002, taking the form of the Energy Performance of Buildings Directive (EPBD). The first directive on the energy performance of buildings (2002/91/EC) was designed to enhance awareness among building users and purchasers, as well as to establish guidelines for the inspection of heating and air condition installations. A series of mandatory standards were established for the construction and renovation of new buildings, and a comprehensive methodology was devised to quantify a parameter that would characterise the energy intensity of a given building. Since then, these measures have contributed to the incremental elevation of standards in the construction sector.

In 2010, the European Parliament directive, 2010/31/EU, was enacted. It was highly ambitious for the time in question in regard to the issue of zero energy. The term nearly zero-energy building (nZEB) was introduced. In accordance with the directive, all newly constructed public buildings were to be designated as nZEBs from 2019 onwards, with this requirement extending to every building from 2021. It

is significant to note that each EU country was permitted to define the requirements for nZEB in accordance with its own specific conditions. Therefore, it is not possible to compare nZEB buildings built in different countries because the initial benchmarks also differ. The directive of 30 May 2018 outlined more substantial changes because it focused on existing buildings (EurLex, 2018). ("Document 32018L0844; Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency)

Its provisions were designed to compel Member States to devise national building refurbishment strategies with the objective of near-total decarbonisation of buildings by 2050, with intermediate targets set for 2030 and 2040. Additionally, there was a focus on the feasibility of new technologies in buildings, and a smart grid readiness indicator for buildings was defined.

The European Green Deal, adopted by the European Commission on 11 December 2019, set the goal of achieving climate neutrality in Europe by 2050, with an intermediate target of reducing emissions by 55% by 2030. In order to achieve this, the aforementioned weighted annual renovation rate of currently 1% would have to be doubled by 2030 and, in the longer term, reach 3% in 2035 and 4% in 2040 (European Climate Risk Assessment). This is in accordance with a study conducted by the Buildings Performance Institute Europe (BPIE) in 2023. The comprehensive thermo-modernisation of European residential buildings could result in a reduction of their heating and air-conditioning demand by approximately 44%, which equates to energy savings of up to 777 TWh. The renovation of existing buildings would lead to a reduction in total EU energy consumption by 5–6% and a decrease in carbon emissions by approximately 5%.

On 14 July 2021, the European Commission adopted a package of measures known as Fit for 55, which forms part of the broader European Green Deal initiative. Its objective was to revise and harmonise the existing legislation across the EU in a manner that ensured consistency between the community's policies and the environmental objectives prepared by the European Council and Parliament. An amendment was also made to the Energy Efficiency Directive, which set out the EU's intention to reduce final energy consumption by 11.7% by 2030, in comparison to the 2020 projections. From 2024 until 2030, the annual target to reduce final energy consumption was to increase successively, with individual Member States required to generate average energy savings of 1.49%.

In a further amendment, less than half a year later, it was decided that more decisive and swifter modifications were needed in the construction industry. On 15 December 2021, the European Commission adopted the Directive of the European Parliament and the Council on the Energy Performance of Buildings (Recast). The primary objective of the directive was to accelerate the renovation of buildings across the EU, with an emphasis on more rapid action in relation to the

15% of buildings that currently demonstrate the poorest energy efficiency. Furthermore, the directive places an emphasis on the promotion of renewable energy sources (RES) and related equipment and technologies, with a particular focus on photovoltaics and heat pumps. Additionally, a definition for a zero-emission building (ZEB) was established. This designation applies to a structure with a primary energy input (EP) of no more than 65 kWh/(m^2-year) that relies on local RESs, is devoid of fossil fuel combustion sources, and has minimal global warming impact, as indicated by its CO_2 equivalent emissions over the course of its lifespan. These buildings are to be considered to surpass previously defined nZEBs (EU Energy Performance of Buildings Directive) (EU the Net-Zero Industry Act).

It would appear that the directives already described and their numerous amendments are sufficient to achieve the desired climate targets in the building sector. This assertion is, in fact, inaccurate. The necessity for further revisions has been a topic of discussion in Brussels for some time. The European Commission's expert panel has determined that the existing requirements will not be adequate for achieving the Fit for 55 objectives, much less the goal of climate neutrality by 2050. It is estimated that up to 90% of buildings constructed prior to 2001 will still be in use by that time. Consequently, there is a need to focus on deepening the renewal wave (REPowerEU Affordable, Secure and Sustainable Energy for Europe).

The European Green Deal commits the EU to becoming climate neutral by 2050 in a manner that does not disadvantage any particular group. To attain this objective, a multifaceted approach is being implemented.

On 12 March 2024, the Commission released a communication outlining strategies for the EU and its Member States to effectively mitigate climate risks. The communication emphasises the need for policies not only safeguarding lives and reducing costs but also promoting long-term economic prosperity in Europe. This is a direct response to the inaugural European Climate Risk Assessment conducted by the European Environment Agency.

Additionally, it addresses the concerns that many Europeans have in the aftermath of last year's historically high temperatures and extreme weather events, which were only surpassed by the summer of 2024. The Commission is therefore calling for action to be initiated by all levels of government, the private sector, and civil society with a view to improving governance and tools for climate risk owners. It points out the requirements for managing risks across sectors and setting the appropriate preconditions for financing climate resilience. In response to these issues, the Commission aims to address them and respond to the initial European Climate Risk Assessment by the European Environment Agency. This is to be achieved through clear communication procedures on managing climate risks in Europe, which set out how the EU and its members can implement policies that will save lives, reduce costs, and protect prosperity. In addition to providing an assessment of the situation, the communication serves

as a call to action for governments at all levels, in addition to the private sector and civil society. The following four principal categories of action have been identified:

- Enhanced governance mechanisms are required to ensure the effective functioning of the system. It would be advisable for EU countries to ensure that risks and responsibilities are better understood. A more integrated approach to climate resilience at the national, regional, and local levels would facilitate the optimal utilisation of knowledge and resources at each level, ensuring the most effective deployment of available resources.
- It is essential to implement more effective instruments for holders to assume greater control over possible risks. Policymakers, businesses, and investors should have a deeper comprehension of the interconnectivity between climate risk, investment, and long-term financing strategies. To assist regional and local authorities in preparing more adequate management systems, the Commission will facilitate access to improved and expanded data and scenarios. Terrestrial alert systems will be supplemented with the Galileo Emergency Warning Satellite Service, which is scheduled to become operational in 2025, with the objective of communicating alert information to the public.
- To effectively manage climate risks across sectors, the communication proposes the implementation of enhanced spatial planning strategies within EU countries, the integration of climate risk considerations into the development and maintenance of critical infrastructure, and the establishment of a coherent framework linking EU-level solidarity mechanisms with nationally-specific resilience measures.
- The optimal conditions for the financing of climate resilience require the mobilisation of sufficient public and private financial resources to enhance climate resilience. The Commission is prepared to provide assistance to member states in order to facilitate improvements and the integration of climate risk budgeting processes within their national budgetary procedures.

The Green Deal Industrial Plan represents a significant step forward in the clean tech revolution, offering a competitive advantage to Europe's net-zero industry and accelerating the transition to climate neutrality. This objective can be achieved through the establishment of an environment propitious to the expansion of the EU's manufacturing capacity for net-zero technologies and products, thereby facilitating Europe's ability to achieve its ambitious climate targets (Document 32019L0944).

The latest revised EPBD was approved on 14 January by the Committee on Industry, Research and Energy (ITRE) and voted on in the European Parliament in March 2024 (Document 32009R0713) (Document 32011R1227)

From 2027, the EU ETS2 is scheduled to be implemented across the EU, which will introduce a levy on emissions from the combustion of fossil fuels in buildings. As a consequence, the cost of heating with coal or

gas boilers will increase directly. In the absence of appropriate assistance and a logical distribution of the associated responsibilities, the transition towards neutrality will have a particularly adverse impact on those with the lowest income levels, resulting in a worsening rather than a reduction of fuel poverty. For example, in its report, 'Impact on Households of the Inclusion of Transport and Residential Buildings in the EU ETS', the Polish Economic Institute estimates that the introduction of ETS2, with a certificate price of €90/t, will result in an increase of up to 42% in expenditure on energy, gas, and other fuels for the poorest 20% of households by 2035.

The Green Deal Industrial Plan is founded upon four core pillars, which collectively aim to consolidate Eur1.1.ope's position as a global leader in industrial innovation and clean technology. A predictable and simplified regulatory environment is a fundamental aspect of the plan. This entails the establishment of a streamlined, accelerated, and foreseeable regulatory structure, the guarantee of requisite raw material quantities, and the assurance of low-cost renewable energy benefits for users. Three initiatives have been identified as providing support for this work. (Document 32024R1252)

(1) Despite the EU's commitment to achieving climate neutrality by 2050, it is currently a net importer of several net-zero technologies and components that are crucial for the realisation of this objective. To guarantee that the green transition is not jeopardised by any potential strategic dependencies, the Commission has put forth a proposal for the Net-Zero Industry Act as a component of the Green Deal Industrial Plan. To achieve these goals, the Commission has set forth a proposal that would set an aggregate manufacturing capacity objective for 2030 while simultaneously simplifying the regulatory framework for net-zero technologies.

The Net-Zero Industry Act: This strategy seeks to enhance the EU's manufacturing capabilities with regard to technologies that are instrumental to the clean energy transition and that, when in operation, release only negligible or zero GHG emissions.

This legislative instrument is designed to attract investment and create more favourable conditions and market access for clean technology within the EU. The objective is to achieve a strategic net-zero technologies manufacturing capacity for the Union of at least 40% of the annual deployment needs by 2030. These measures will serve to expedite the progression towards the EU's 2030 climate and energy objectives, in addition to the anticipated transition to climate neutrality by 2050. Moreover, it is anticipated that this will enhance the competitive position of the EU industry, generate quality employment opportunities, and support the EU's objective of becoming energy-independent. Additionally, the Act streamlines the regulatory apparatus governing the manufacture of these technologies. This will assist in enhancing the competitive position of the net-zero technology industry in Europe and facilitate the expansion of CO_2 storage capacity. (The Net-Zero Industry Act)

The Act addresses technologies that are expected to contribute considerably to decarbonisation. In particular, the Act provides support for strategic net-zero technologies that are already commercially available and demonstrates significant potential for rapid scale-up. The utilisation of such technologies serves to bolster the industrial competitiveness and resilience of the EU's energy system whilst facilitating the transition to clean energy. The key technologies under consideration include solar photovoltaic and solar thermal units, batteries and storage, electrolysers and fuel cells, carbon capture and storage, heat pumps, and geothermal energy. In addition, the measures set out in the Act support a range of other net-zero technologies, including sustainable alternative fuel technologies, advanced technologies for energy generation from nuclear processes with a minimal environmental footprint, small modular reactors, and related high-quality fuels.

In order to encourage capital investment in technologies that achieve net-zero emissions, the Act puts forward a series of recommendations:

- Net-zero strategic projects: The identification of priority projects that are essential for the reinforcement of the resilience and competitiveness of the EU net-zero industry.
- Enforcement of accelerated permitting: The reduction of the administrative burden associated with the development of net-zero manufacturing projects, coupled with simplified and expedited permitting procedures. This is particularly relevant for strategic projects, which will benefit from accelerated permitting procedures that increase planning and investment certainty.
- The objective is to enhance the capacity for CO_2 carbon capture and storage projects by enhancing the availability of CO_2 storage sites.
- The aim is to attract investment through the Net-Zero Europe Platform and the European Hydrogen Bank.
- The intention is to facilitate access to markets by implementing sustainability and resilience criteria in procurement procedures and auctions.
- The objective is to boost demand for renewables by establishing regulatory procedures supporting the development and testing of innovative net-zero technologies.
- The goal is to enhance skills by setting up Net-Zero Industry Academies. These will be supported and overseen by the Net-Zero Europe Platform. Such initiatives will facilitate the training and education of personnel in net-zero technologies, thereby contributing to the creation of quality employment opportunities.

The utilisation of hydrogen represents a pivotal technology within the framework of the Net-Zero Industry Act, a strategic initiative spearheaded by the EU. It is imperative that European industry undergo a decarbonisation process in order to achieve the EU's 2030 climate targets and 2050 climate neutrality. By increasing the scale of production, the use of fossil fuels in European industry will be reduced, while the needs of sectors that are difficult to electrify will be met. The European Hydrogen Bank will facilitate the uptake of renewable hydrogen within the EU as well as imports from international partners. The objective is to facilitate private

investment in hydrogen value chains by ensuring an efficient connection between renewable energy supply and demand while addressing the initial investment challenges. The Bank will facilitate the emergence of a new European hydrogen market, stimulate economic growth and job creation, and assist the EU in achieving its hydrogen-related objectives, in alignment with the REPowerEU initiative and the path towards climate neutrality (EC 16 March 2023).

(2) In order to meet climate and digital objectives, the following challenges must be addressed: Sourcing, processing, and recycling of critical raw materials within Europe and the securing of supply chains. A variety of materials are used in the production of batteries, including lithium, cobalt, and nickel. Gallium is employed in solar panels, while raw boron is utilised in wind technologies. Titanium and tungsten are utilised in the space and defence sectors. In order to guarantee the stable and environmentally friendly provision of essential raw materials for European industry and to considerably reduce the EU's reliance on imports from a single country, the European Raw Materials Act sets out a framework for ensuring the security of supply. It serves as the foundation for developing the EU's capabilities and enhancing the resilience of its essential raw material supply chains. This encompasses the implementation of strategies aimed at bolstering domestic supply chains and forging collaborative relationships with international partners. The following key pillars of the Act should be discussed:

- Action priorities: The Act identifies a list of critical raw materials and a list of strategic raw materials, both of which are considered crucial for a number of different technologies, including those that facilitate the green and digital transition. Furthermore, the legislation outlines the desired benchmarks for domestic capabilities within the strategic raw material supply chain to be attained by 2030. These include 10% of the EU's annual extraction requirements, 40% for processing, and 25% for recycling. Additionally, the legislation stipulates that no more than 65% of the EU's annual requirements for each strategic raw material at any stage of processing should originate from a single third country.
- Capacity growth: It is imperative that the EU reinforce its capacity for the processing and recycling of raw materials. This necessitates strengthening the entire chain from mining and extraction to refining and manufacturing. To achieve this goal, it will be necessary to implement measures to facilitate the advancement of national exploration initiatives, streamline and enhance the predictability of permitting procedures, and facilitate access to financial resources.
- Enhancing resilience issues: The overarching objective of this pillar is to enhance the EU's capacity to withstand disruptions in the supply chain. This will be achieved through a combination of measures, including enhancing the monitoring capacity via the implementation of stress tests, ensuring coordinated initiatives to establish strategic stockpiles, and encouraging sustainable investment and trade. The EU will invest in research, innovation, and skills development in order to facilitate the uptake and deployment of breakthrough technologies in critical raw materials. The establishment of a large-scale

skills partnership on critical raw materials and of a Raw Materials Academy will promote skills relevant to the workforce in critical raw materials supply chains.

- Implementation of a raw materials economy: The promotion of recycling and the establishment of a robust secondary market are crucial for the sustainable management of raw materials. These goals can be achieved by fostering the recovery of critical raw materials from extractive waste facilities while simultaneously intensifying efforts to mitigate adverse impacts with respect to labour rights, human rights, and environmental protection. Furthermore, the recognition of certification schemes that enhance the sustainability of critical raw materials in the EU market is essential.

The EU is significantly reliant on the import of vital raw materials from external sources. Our current level of dependency, when considered in conjunction with the growing global demand associated with the transition towards a digital and green economy, increases the vulnerability of supply chains. The scope of imported materials includes 63% of the world's cobalt, used in batteries, extracted in the Democratic Republic of Congo; 97% of the EU's magnesium supply is sourced from China; 100% of the rare earths used for permanent magnets are refined in China; 98% of the EU's supply of borate is provided by Türkiye. It is therefore evident that international trade is of paramount importance for supporting global production and ensuring the diversification of supply (EU. European Critical…).

The EU pursues mutually advantageous collaborations with emerging markets and developing economies, particularly within the context of its Global Gateway Strategy. To reinforce global supply chains, the EU intensifies its trade actions. These include the establishment of a Critical Raw Materials Club, which will be open to all like-minded countries. The EU will also seek to reinforce the World Trade Organization (WTO), expand its network of Sustainable Investment Facilitation Agreements and Free Trade Agreements, and combat unfair trade practices.

(3) The EU's electricity market is poised to witness a significant shift in its energy mix, with an anticipated increase in the share of electricity generated from renewable sources, particularly solar and wind, from 37% in 2020 to over 60% by 2030. As reported by Eurostat in 2022, the proportion of gross electricity consumption within the EU accounted for by renewable sources reached 41.2%. Concurrently, it is essential to produce and deliver electricity in adequate quantities when there is no wind or sun.

It is essential for the market to evolve to facilitate the integration of renewable energies and to encourage investment in fossil-free flexible technologies, such as demand-side response and energy storage, complementing variable energy production. Incentives must also be provided to encourage consumers to become more active and to contribute to ensuring the stability of the electricity system. (Document 32011R1227)

It is essential that the EU electricity market is transparent and efficiently monitored in order to guarantee open and fair competition while also protecting against any potential market abuse or manipulation. In 2022, energy prices reached elevated levels and displayed considerable volatility. These developments gave rise to significant concerns regarding the security of the energy supply. In response, EU representative countries called upon the Commission to pursue a structural reform of the electricity market to enable Europe to attain greater energy sovereignty while simultaneously achieving the goal of climate neutrality.

In order to stimulate the growth of RESs, safeguard consumers, and bolster industrial competitiveness, the Commission put forth a proposal to reform the existing electricity market regulations in March 2023. This initiative was part of the Green Deal Industrial Plan.

The new electricity market design rules comprise an amending directive (EU/2024/1711) and an amending regulation (EU/2024/1747). The aforementioned legislative instruments were adopted on 21 May 2024 and entered into force on 16 July 2024.

The Electricity Directive (EU/2019/944) and the Electricity Regulation (EU/2019/943) establish a framework for the internal market for electricity that prioritises the consumer. This framework enables active participation in the transition to clean energy and provides a robust framework for consumer protection. These regulations permit a greater degree of flexibility, thereby accommodating the growing proportion of renewable energy on the grid and thus contributing to the creation of green jobs and economic growth.

The ACER Regulation (Regulation (EC) No 713/2009) established the Agency for the Cooperation of Energy Regulators (ACER), and it was recast with Regulation (EU) 2019/942 as part of Clean Energy for All Europeans.

The role of ACER is to act as an independent body with the objective of fostering the integration and completion of the European internal energy market for electricity and natural gas. In addition to these responsibilities, the agency is tasked with coordinating the actions of national energy regulators at the European

level, developing shared network and market standards, participating in regional and cross-regional initiatives, monitoring market activity, and providing guidance to EU institutions on matters related to trans-European energy infrastructure development and security of supply.

The Wholesale Energy Market Integrity and Transparency (REMIT) Regulation (EU/1227/2011) is designed to foster confidence among consumers and other market participants in the integrity of the electricity and natural gas markets. It aims to ensure that prices are fair and competitive based on supply and demand and that no profits can be drawn from market abuse.

The revised Renewable Energy Directive concentrates on the flexibility of an energy system as a key determinant of its stability and capacity to integrate renewable energy. A flexible energy system can accommodate rapid changes in generation, storage, and consumer demand, which in turn can contribute to more stable prices and greater integration of renewable energy. The Renewables Directive (EU/2018/2001) was subsequently amended by Directive (EU/2023/2413), which entered into force on 20 November 2023.

The revised regulations are designed to reinforce resilience within the EU energy market while also seeking to diminish the extent to which the energy expenditure of both consumers and corporations is contingent upon the immediate fluctuations of electricity market pricing. This can be achieved through the use of long-term contracts, including power purchase agreements, as well as the implementation of two-way contracts to support investment.

Additionally, the reform will facilitate the accelerated deployment and integration of a greater proportion of RESs within the energy system. Furthermore, it will enhance protection against market manipulation, thereby promoting the stability and predictability of energy prices and contributing to the competitiveness of the EU's industry.

The EU Taxonomy is the colloquial name for Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on establishing a framework to facilitate sustainable investment. The legislation has the objective of increasing the level of environmental protection by redirecting capital from environmentally damaging investments to greener alternatives. In accordance with Regulation (EU) 2020/852 of the European Parliament and the Council, the construction or renovation of buildings is one of the economic activities that is subject to assessment as to whether it qualifies as a sustainable economic activity, as an environmentally sustainable activity, or as an activity that is environmentally weighted. Furthermore, the Taxonomy encompasses the production of cement, steel, and aluminium and the manufacture of building products and installation components that enhance the energy efficiency of buildings. The regulation sets out the following environmental objectives, which should be pursued according to the concept of doing no significant damage:

1 Mitigation and adaptation of climate change: Where risk assessment must be conducted in relation to potential climate-related impacts for the site in question.

This assessment encompassed a range of hazards, including heavy rainfall, lightning, strong winds, floods, landslides, fires, and the occurrence of heat and cold waves.

2 Sustainable use and conservation of water and marine resources: Where the implementation of technical measures ensures the optimal flow rates of water in wash basins, sinks, showers, toilets, and urinals, in accordance with the maximum permissible levels.

3 Transition to a closed-cycle economy: Where a minimum of 70% (by weight) of non-hazardous construction and demolition waste should be suitable for reuse, recycling, and other material recovery processes. Design and construction techniques that consider the circularity and closed cycle in accordance with ISO 20887 or other standards, assessing the feasibility of dismantling or adapting the building for a changed use.

4 Pollution prevention and control: The building components and building materials used in construction must be in compliance with the established criteria. Specifically, regarding the use and presence of chemicals and the attainment of maximum allowable emission levels. Furthermore, the use and presence of chemicals comply with the maximum permissible levels of emissions of formaldehyde and carcinogenic volatile organic compounds from building components and materials. In the event of a new construction project taking place on a previously degraded site, the site must undergo a comprehensive examination to identify any potentially harmful contaminants. In order to minimise the potential impact of construction and maintenance activities on the surrounding environment, robust measures shall be implemented to control and reduce emissions of noise, dust, and pollutants.

5 Protection and restoration of biodiversity and ecosystems: An environmental impact assessment must be conducted and the necessary mitigation and compensation measures put in place (this issue does not apply to building renovation). These measures are intended to facilitate reconciliation and compensation for environmental protection reasons. In the case of sites or activities situated in or in the vicinity of biodiversity significance areas, including the Natura 2000 network, UNESCO World Heritage sites, and areas of particular importance for biodiversity, an appropriate assessment will be conducted in accordance with the relevant criteria. The significance of the area for biodiversity, as well as other protected zones, shall be evaluated in accordance with the relevant standards. Based on the findings of this evaluation, the necessary mitigation measures have been implemented in line with the recommendations. The construction of new buildings is prohibited on land that is currently being used for agriculture and is characterised by a medium to high level of soil fertility and rich in subterranean biodiversity, as well as land that has not yet been developed and is of great importance for the preservation of biodiversity and acts as a habitat for endangered species listed in accordance with the IUCN Red List. Additionally, land forest definitions under national law shall also be included. In cases where the national GHG balance includes land that does not correspond to the definition of a forest established in any national law

but is nevertheless considered a forest by the Food and Agriculture Organization of the United Nations (FAO), the latter definition shall apply (Gerylo and Garbacz, 2022).

There are several criteria with regard to climate change mitigation objectives. In the case of building construction projects, the initial primary energy demand (energy performance) of buildings is at least 10% lower than the threshold set in the many national requirements for near-zero energy buildings. In addition, in the case of buildings exceeding 5000 m^2, the buildings shall be subjected to airtightness and thermal imaging tests. Furthermore, investors and customers shall be informed of any defects in the building envelope and of any noncompliance with the energy performance targets. Global Warming Potential (GWP) is determined for each lifecycle stage and expressed in kg of carbon dioxide equivalents per m^2 of usable floor area and year (average over 50 years). The selection of data and the definition of scenarios and calculations are carried out in accordance with the requirements set out in EN 15978, Sustainable construction products – assessment of environmental performance of buildings – calculation method. The range of construction elements and technical equipment is consistent with the scope of those elements and equipment defined at the EU level for indicator 1.2 or, alternatively, in accordance with other calculation tools, provided that such tools satisfy the minimum criteria set at the EU level.

In the case of building renovation processes, the project should comply with all relevant national requirements and dimensions. Furthermore, it should result in a reduction in the primary energy demand of at least 30%. The primary energy demand and its estimated reduction are determined on the basis of a detailed building survey, an energy audit carried out by an independent expert accredited in the field, or any other transparent and proportionate methodology. In addition, an energy performance certificate must be obtained to establish a baseline from which improvements can be evaluated. This should be based on the actual primary energy demand reduction, excluding any reduction due to energy performance certification. It should also be kept in mind that this reduction should take into account the actual primary energy demand and should not include any reduction resulting from RESs. It is also important to note that this reduction can be achieved through successive measures over a period of no longer than three years.

1.4 Conclusions

On 12 March 2024, the European Parliament adopted an amendment to the EU EPBD, which introduces new energy efficiency requirements for buildings in the EU. From 2030, new buildings will be constructed in accordance with the principles of zero-emission, while existing buildings will be progressively upgraded to this standard by 2050. The new legislation presents a number of challenges and obligations for the member states, including the preparation of national strategies and financial and advisory support programmes. However, it is also expected to bring a number of benefits, both environmental and economic. This is of particular

significance, given that the construction industry currently represents a significant contributor to global GHG emissions.

A report from the European Commission indicates that approximately 85% of buildings in the EU were constructed prior to 2000, with three-quarters of these exhibiting suboptimal energy performance. This makes buildings the largest energy consumers in Europe. In 2021, 42% of all energy consumed in the EU was used in buildings, which are also the source of approximately one-third of the EU's GHG emissions. It is therefore evident that the decarbonisation of this sector is a key factor in achieving the EU's energy and climate neutrality targets by 2050.

In practice, the new legislation stipulates that from 2030 onwards, all new buildings constructed in the EU are to be zero-emission (with the exception of all new public administration buildings, which are to be zero-emission from 2028 onwards). Furthermore, existing buildings will be converted to zero-emission by 2050 at the latest. With regard to residential buildings, it is incumbent upon Member States to implement measures that will result in a reduction of the average primary energy consumption by a minimum of 16% by 2030 and by a further minimum of 20–22% five years later. It is anticipated that the amendment will facilitate the renovation of buildings with the poorest performance, commonly described as energy vampires. Consequently, 55% of the aforementioned reduction is to be achieved in such buildings. In addition, EU Member States will be required to renovate 16% of non-residential buildings with the poorest energy efficiency by 2030 and 26% by 2033. This will be facilitated by the introduction of minimum energy performance requirements.

The revised EPDB Directive also contains a prohibition on the provision of subsidies for the purchase of solid fuel boilers, with the effect that subsidies for the purchase of gas boilers will no longer be available (for example) under the Clean Air programme. It is incumbent upon Member States to implement policies that will facilitate the decarbonisation of heating systems and the gradual elimination of fossil fuels in heating and cooling technologies. This process will culminate in the complete phase-out of fossil fuel boilers by 2040. If technically and economically feasible, the installation of photovoltaic installations will also be phased in, initially on the roofs of new and retrofitted public and non-residential buildings and, in time, residential buildings.

Furthermore, the revised Directive introduces a definition of indoor environmental quality and a recommendation for developing indoor climate quality requirements. Given that individuals spend 90% of their lives in buildings, it is important that they are healthy buildings. To support these issues, New Bauhaus has developed a set of measures and criteria, leading to the development of user health and wellbeing expectations.

In accordance with the stipulations outlined in Article 7 and Article 11, all buildings constructed subsequent to 1 January 2030 are required to attain the designation of ZEB. Consequently, these buildings must

exhibit exceedingly high energy efficiency, minimal energy demand, and the absence of CO_2 and other GHG emissions resulting from the utilisation of fossil fuels. With the introduction of the ZEB standard, the EU's energy and building policy framework has undergone a significant transformation. This novel requirement has supplanted the nZEB standard previously established in previous versions of the EPBD. The amendment underscores the EU's heightened expectations with regard to sustainability, energy efficiency, and GHG reduction in the context of the building sector. The nZEB represented a significant advance in efforts to enhance the energy efficiency of buildings in Europe. It underscored the necessity of drawing energy from renewable sources.

All Member States are obliged to ensure that energy demand and operational GHG emissions for new and retrofitted buildings align with the maximum threshold limits established at the national level. Concurrently, the annual primary energy consumption of ZEB facilities must include the following:

- RESs generated on-site or locally;
- Renewable energy provided by a community or RES cooperative;
- Energy from efficient district heating and cooling, in accordance with the new EPBD requirements;
- Energy from carbon-free sources.

Heat pumps are particularly suited to this context due to their high efficiency and their role in meeting these requirements. The use of electric heat pumps, supported by photovoltaic systems, represents one of the principal solutions for achieving the new required standards in new ZEB buildings. This approach allows a building's annual electricity requirements to be offset by the annual energy production from domestic photovoltaic systems or community RES, thus ensuring high energy efficiency and minimising GHG emissions.

In accordance with Article 3 and Annex II of the revised EPBD, Member States are obliged to develop national renovation plans for all buildings with the objective of decarbonising the heating and cooling sector.

These long-term building renewal strategies are to be updated every five years and are intended to ensure the transformation of the building stock towards achieving a ZEB standard by 2050. The initial plans are to be presented by the end of 2025, and the finalised plans are to be submitted by the end of 2026.

The plans comprise several key elements. First, a review of the national stock is required, distinguishing between different building types according to the construction period. Second, a review of market barriers and capacity is necessary in the construction, energy efficiency, and renewable energy sectors. Third, the share of vulnerable households must also be taken into account. Furthermore, the plans are to include the following:

1 A list of actions with nationally set targets for building decarbonisation and measurable indicators for their achievement, as well as targets for reducing the number of people in fuel poverty.

2 An outline of investment needs, sources, and means of financing and administrative resources to implement building renovation plans.
3 An overview of policies and measures for the decarbonisation of heating and cooling systems, including through district heating/cooling networks, and the phasing out of fossil fuel boilers with a plan to remove them completely by 2040.

This evidence demonstrates the imperative for the building market to evolve in accordance with the introduction of novel green technologies, such as heat pumps.

Verification of compliance with the EU Taxonomy is a prerequisite for obtaining financing on more favourable terms, given that the EU Taxonomy facilitates the green financing of investments that align with environmental objectives and criteria.

It is recommended that verification be conducted at the conceptual stage. This enables the optimisation of the project, for example, in terms of energy efficiency or circular economy solutions, and the application of the requisite procedures and the performance of the relevant analyses required by the EU Taxonomy.

An analysis conducted at the execution or postconstruction stage is typically insufficient to meet the taxonomic criteria. Nevertheless, such an analysis allows for the identification of key learnings that can be implemented in the design of future projects, ensuring the incorporation of optimal solutions and mitigating potential challenges. Furthermore, the verification of compliance with the EU Taxonomy at the level of individual buildings will enable the calculation of the financial capital expenditures (CAPEX) and operating expenditures (OPEX) indicators associated with a company's operations.

The scope and procedures vary from country to country, depending on the level of advancement found in legislation. Key solutions for installing, maintaining, and repairing energy-efficient equipment are of particular importance. The activities in question include one of the following individual measures, provided that such measures comply with the minimum requirements set forth for individual elements and systems in the applicable national measures implementing Directive 2010/31/EU. Furthermore, they must belong to the two highest energy efficiency classes in accordance with Regulation (EU) 2017/1369 and the delegated acts adopted pursuant to them.

a The addition of insulation to existing building envelope elements, including external walls (including green walls), roofs (including green roofs), attics, basements, and ground floors (including measures to ensure airtightness and measures to reduce the effects of thermal bridging and scaffolding), and insulation products for the building envelope (including mechanical fixings and adhesive).
b Replacement of existing windows with new energy-efficient windows.
c Replacement of existing external doors with new energy-efficient external doors.
d The installation and replacement of energy-efficient light sources.
e The installation, replacement, maintenance, and repair of heating, ventilation, and air-conditioning (HVAC) systems and water heating systems, including

equipment related to district heating services, with highly efficient technologies, as well as the maintenance and repair of associated elements.

Furthermore,

a Installation, maintenance, and repair of photovoltaic systems and additional technical equipment.
b Installation, maintenance, and repair of photovoltaic panels for water heating and additional technical equipment.
c Installation, maintenance, repair, and upgrading of heat pumps – contributing to the achievement of renewable energy targets in the heating and cooling sector in accordance with Directive (EU) 2018/200113 – and additional technical equipment.
d Installation, maintenance, and repair of wind turbines and additional technical equipment.
e Installation, maintenance, and repair of unglazed solar collectors and additional technical equipment.
f Installation, maintenance, and repair of thermal or electrical energy storage units and additional technical equipment.
g Installation, maintenance, and repair of highly efficient micro-cogeneration units.
h Installation, maintenance, and repair of heat exchange/recovery systems.

For outside building stock technical upgrades, one of the major issues is adaptation to climate change. The principal physical climate risks have been identified in the EU standards and isolated from the broader range of risks; hence, preliminary indications have emerged suggesting the implementation of targeted control activities, such as

a The screening of activities to identify which climate-related physical risks are likely to affect the conduct of the business during its expected life cycle.
b An assessment of climate change adaptation solutions that may reduce identified climate-related physical risks.

The climate risk and exposure assessment must be commensurate with the scale of the activity and its anticipated duration.

a For activities with an expected duration of less than ten years, the assessment shall be conducted using at least the smallest appropriate-scale climate projections.
b For all other activities, the assessment shall be conducted using the most highly resolved state-of-the-art climate projections with a range of future scenarios, consistent with the expected lifetime of the activity. This shall include at least scenarios involving climate projections over a 10–30-year period for large investments.

The climate projections and impact assessment must be based on the most up-to-date best practices and available guidance (New European Bauhaus Compass). Furthermore, they must take into account the latest scientific knowledge in exposure and hazard analysis and related methods in line with the most recent reports of the IPCC.

These changes can already be seen in some of the available environmental certification procedures (i.e. version 6 of BREEAM Rsc 04 Future adaptation). The assessment criteria cover the issues, confirming that the building has been designed with such a degree of flexibility to ensure that future changes in use are possible. This flexibility shall consist of at least two of the following:

a Partition walls that can be easily repositioned.
b A flexible internal vertical load-bearing structure design with a regular column layout and few or no load-bearing walls.
c Building services that can be easily removed/adapted when areas are unoccupied or when there is increased usage required (e.g. HVAC grille and luminaire removal or addition).
d Floor plan shapes, primary circulation routes, and floor-to-floor heights that are suitable for a number of potential future uses.

The functional adaptation strategy study should consider the following (Table 1.1):

a Feasibility: The likelihood of containing multiple or alternative building uses, area functions, and different tenancies over the expected life cycle (e.g. related to the structural design of the building).
b Accessibility: Design aspects that facilitate the replacement of all major plants within the life of the building (e.g. panels in floors and walls that can be removed without affecting the structure, providing lifting beams and hoists). Accessibility also involves access to local services, such as local power, data infrastructure, and so on.
c Versatility: The degree of adaptability of the internal environment to accommodate changes in working practices.
d Adaptability: The potential of the building ventilation strategy to adapt to future building-occupant needs and climate scenarios.
e Convertibility: The degree of adaptability of the internal physical space and external shell to accommodate changes in use.
f Expandability: The potential for the building to be extended horizontally or vertically.
g Refurbishment potential: The potential for major refurbishment, including replacing the façade.

The implementation of this approach has the potential to reduce the waste and costs associated with future refurbishment or fit-out works, as well as demolition. It can also enhance the capacity to cost-effectively reuse and recycle materials, increase the lifetime value of materials and products, and encourage the consideration

Table 1.1 Information on future adaptation design measures presented in an office case study

Data indicating potential adaptation possibilities for future upgrades of an office building in Warsaw

	Accessibility	*Convertibility*	*Expandability*
Structural elements • External walls • Cladding • Ground and first floor • Roof	Solutions for easy replacement were used. The external walls are constructed as a curtain-type façade without transom, with both translucent and opaque fields. This type of façade is relatively easy to dismantle and replace with another solution without disturbing the load-bearing elements of the building's structure. There is virtually no cladding in the building, with the exception of the walls in the entrance halls where stone slabs of a typical module are used, which can be easily removed and used in other areas of the building. The roofs of the building (levels +4 and +6) are used as social spaces, while the roof at level +7 is used as a technical space. This arrangement allows easy access to the maintenance of the main technical equipment serving the building.	In the building, an imposed load of −3.5 kN/m^2 was adopted for the office areas. Only local loads of 5.0 kN/m^2 have been adopted. This means that the function of the building can only be changed in terms of the assumed loads. However, the location of the structural elements (columns and 2 communication cores) on the open plan, together with the free plan, indicates the variety of possible layouts. The system glass façade solutions are used to meet the comfort and acoustic insulation requirements for a residential building; thus, it is possible to change the function from office to residential in any part of the building. It is possible to consider whether the roofs of the building could ultimately be used as green recreational spaces and the roof on the top floor as a place to set up bee hives.	The conditions set in the Land Development Conditions indicate that there is no possibility to extend the building vertically. The building has been constructed in accordance with the mandatory building lines, so there is no possibility of extending the building horizontally due to the overshadowing of the existing residential buildings, which resulted in the need to carve up the façade and obtain a variance. The undeveloped space on the roof should remain a green space; alternatively, it could be used for solar energy infrastructure (photovoltaic panels).

(*Continued*)

Table 1.1 (Continued)

Data indicating potential adaptation possibilities for future upgrades of an office building in Warsaw

	Accessibility	*Convertibility*	*Expandability*
Main and local installations • Mechanical and electrical • Sanitary • Vertical communication (stairwell and lift shafts)	The energy performance certificate for building X was issued in 2020 and is valid until 2030. The performance specifies: a The energy balance of the electrical and non-electrical consuming appliances constituting the building's fixed installation equipment, with a separation of the power of the technological equipment related to the building's intended use. b Energy performance of the external envelope, including solid walls and doors, gateways, as well as transparent and other partitions. c Energy efficiency parameters for heating, ventilation, air-conditioning, or refrigeration systems, and other appliances have an impact on the energy management of the building. d Data demonstrating that the installation solutions adopted in the architectural and construction design meet the energy-saving requirements of the technical and construction regulations, while in the case of construction solutions, it is necessary to take measures to improve the energy efficiency of the facility.	The mechanical-electric units are fed from the municipal grid. In Poland, the primary fuel used in municipal grids is hard coal. In the future, the fuel structure will probably change in favour of alternative energy sources. The building under study has an EP factor of 268.11 kWh/(m^2 year), indicating very low energy performance. An energy audit is suggested as a feedback document for the management of building use. It would be possible to install photovoltaic cells in the upper part of the façade. For the purposes of sanitation balances for the office areas, a ratio of approximately 10 m^2/person of the total office area was assumed. The designer has included in the assumptions the possibility of changing the number of intakes in the building, depending on the number of users. In the case of vertical communication, it will be necessary to change the lifts to more energy-efficient ones in the future.	The parameters of the sanitary and mechanical/electrical installations allow that if, as a result of the subdivision, workplaces employing more than 20 women per shift are created for the tenants, a room with restrooms for pregnant women and nursing mothers should be provided. In addition, technical rooms with connections installed on each floor allow for easy distribution of utilities to individual tenants.

(*Continued*)

Table 1.1 (Continued)

Data indicating potential adaptation possibilities for future upgrades of an office building in Warsaw

	Accessibility	*Convertibility*	*Expandability*
	The sanitary risers were placed close to the circulation stalls, which is an optimal solution. Vertical communication has been arranged in accordance with the design guidelines (i.e. stairs and lifts in each shaft). This is an optimum solution from the point of view of building services.		
Fire prevention requirements	As recorded under ABC, the building is categorised as a medium-rise building. For future activities, this means that the building can fulfil all the functions of a public facility, with the exception of those with separate rooms that can accommodate more than 50 people at a time who are not permanent users (e.g. cinema or school), and it must not be intended for people with reduced mobility (people with disabilities, children, or the sick), which does not mean that it does not meet the requirements of an accessible building.		

(*Continued*)

Table 1.1 (Continued)

Data indicating potential adaptation possibilities for future upgrades of an office building in Warsaw

	Accessibility	*Convertibility*	*Expandability*
Interior design • Finishing • Flooring • Interior walls • Connections	The use of products or systems that allow for easy replacement: In offices, raised floors and partially suspended ceilings were used. In the service areas, suspended ceilings are used, leaving the reinforced concrete ceilings exposed. Internal walls are made of gypsum board or light masonry construction, with the exception of reinforced concrete shafts for communication risers. Connections are routed in vertical shafts and then, depending on the arrangement, in raised ceilings and suspended ceilings. All floor-mounted equipment is flush with the floor level (electrical boxes, trench heaters, wipers, etc.).	Standardised materials were used in the design and during implementation. Thus, both the rearrangement of the subleased premises (i.e. the offices) can be easily changed and modernised according to the changing needs of the users. The above-mentioned assumptions apply to the raised floors, the internal plasterboard walls, and the connection points to the risers, where sub-metering for individual utilities has also been located.	At a time when remote working and flexible working models are becoming the new norm, the office is expected to be a space that positively impacts employee productivity, and the safety of those working there has become a priority. Employees now expect employers to optimise their working environment. The ability to freely arrange the space provided in the building surveyed enables the space to be used effectively to change the number of users and to change functions. Overwhelmingly, experts analysing the market expect a reduction in the number of office occupants. However, this does not mean that tenants will occupy significantly less space than before the pandemic, but they will certainly use it differently.

of circular economy principles during the life of the asset. Furthermore, it can reduce the costs and disruption associated with the need for future adaptation, demolition, and strip-out, thereby reducing the associated waste and costs.

The scope of preventing climate change also covers retention and efficient water usage, both on the building level and in urban scales. Where possible, the implementation of bio-based building materials or recycled and repurposed materials should be developed to a much higher level. This approach must also allow for often numerous legislation modifications and for a changed approach to urban planning. Part of the changes implies further development of the ESG contents, with acceptance of definite aims to be reached in the assumed time. The changes also encompass modernisation and fit-out works provided in existing buildings.

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