Environmentally relevant future topics

FROM QUANTUM COMPUTING TO THE FUTURE OF INNER CITIES TO A NEW WORLD (DIS-)ORDER

Results of the second horizon scanning cycle for UBA and BMUV

For our environment

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Table of contents

List of figures

1

Disruptions on the horizon

1 Introduction: Disruptions on the horizon

1.1 Horizon scanning in times of Covid-19 and Russia's war of aggression on Ukraine

When the first people in Germany contracted Covid-19 in the spring of 2020, it was not possible to foresee how quickly and extensively the pandemic would have an impact at home and abroad. In the same period, work began on this, the second, cycle of horizon scanning for the German Environment Agency (Umweltbundesamt – UBA) and the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz – BMUV)[1]. The early identification of emerging environmentally relevant or environmentally significant topics thus took place under the impression of the pandemic. At the beginning of the scanning cycle, it was not yet possible to imagine the course the Covid-19 pandemic would take and the profound changes it would lead to in society, politics and at the individual level.

Some of the identified topics were directly influenced by the Covid-19 pandemic. They were either reinforced in their already previously recognisable development or slowed down. Examples of this are *mobile work* (see chapter 2.6), the *future of city centres* (see chapter 2.10) or the *resilient society* (see chapter 2.5). It is clear that future developments with regard to these topics will no longer be primarily determined by the Covid-19 pandemic and will also be of importance for the UBA and BMUV in the long term.

The topics of the second cycle were identified in the first and second year of the pandemic and even now – with the publication of this report – the Corona crisis has not yet been overcome. In February 2022, with the start of the Russian war of aggression in Ukraine, another event occurred that will also influence some of the topics already identified and possibly change their further development in the longer term or even permanently e.g. the chapters on the *future of the EU* (see Chapter 2.7) and a new *world (dis)order* (see Chapter 2.8).

At this point, it should therefore be noted that the topics identified and worked on in this report reflect the current state of knowledge. Depending on the dynamics of the future topic, an attempt was made during the project period to be as up to date as possible. In particular, the topics in chapters 2.5, 2.7 and 2.8 that have been influenced by the war in Ukraine were updated between April and June 2022, while the other chapters are up to date as of the end of March 2022.

In strategic foresight, both the pandemic and the Russian war of aggression against Ukraine are referred to as black swans or wild cards, i.e. events that only occur with a low probability but whose effects can be dramatic (Steinmüller and Steinmüller 2004; Taleb 2016). For example, the occurrence of a pandemic and its effects were already described in 2012 as a scenario within the framework of a risk analysis by the Federal Office of Civil Protection and Disaster Assistance (BBK) in coordination with the Federal Ministry of the Interior (BMI) and discussed by the Federal Government (Deutscher Bundestag 2013, p. 4). Even though it was stated that a pandemic could occur (the probability of occurrence being once in a period of between 100 and 1,000 years), it was uncertain when this event could occur (Deutscher Bundestag 2013, p. 56). In the current situation, the public interpreted the report to the effect that no adequate reaction took place despite a warning ten years in the past. The impression was that all the necessary information was available – both about the possible effects of a pandemic and about the measures to be taken to protect the population. This is an example of the purpose for which strategic foresight could be used and how important proactive policies are.

Strategic foresight, especially horizon scanning, is an approach to detect and interpret signals for change at an early stage and to derive options for action from these interpretations. Especially in times

1 Results of the first cycle available at: https://www.umweltbundesamt.de/publikationen/von-blockchain-ueber-raumfahrt-bis-virtuellen

when many complex and dynamic developments influence each other and disruptive events have global consequences, the early creation of orientation knowledge and its communication are of particular importance. This became especially clear in the early days of the Covid-19 pandemic. The duration and the scope of the pandemic were still completely unclear and reliable medical knowledge was not yet available. However measures had to be taken quickly to protect the population and therefore a high degree of uncertainty arose. As a reaction, more and more orientation knowledge was developed in the form of images of the future for a time after the pandemic. When exactly this time would start remained unclear (cf. e.g. Glockner et al. Glockner et al. 2020 and European Parliamentary Technology Assessment (EPTA) 2021).

In the broad debate on the post-pandemic world, topics came into focus that are partly reflected in this HS report because they are of great environmental relevance or can influence the way the UBA and BMUV work. For example, although the discussion on *more climate-neutral aviation* (see chapter 2.3) was already underway before the occurrence of the Covid-19 pandemic, many arguments were given an additional push by the global drop in air traffic during the time of the initial lockdowns. In addition, a focus on a *new regionality* was placed in this report (see chapter 2.4), which also resulted, among other things, from the effects of the lockdowns imposed in Germany, but also from the vulnerability with regard to energy and food supplies that is now being felt. The *change in the world of work* due to the temporarily necessary or mandatory relocation of the place of work to one's own home (see Chapter 2.6) is also one of the developments that were already recognisable before the pandemic. However, this development gained considerable momentum due to the restrictions that were introduced.

In the meantime, however, it has become apparent that over the duration of the pandemic some of the developments are again pointing in a completely different direction. For example, demand for air travel has increased significantly again due to catch-up effects, although a renewed trend reversal is conceivable with the start of the Russian war against Ukraine (Kohlmann 2022).

The question of whether remote, location-independent working and the decreasing demand for office space will last in the long term, or whether a new form of presenteeism may emerge, cannot be conclusively clarified, at least for the near future. From the project's point of view, it is important to sound out ideas for the scope for political action within the possible developments in the topics of the future.

The Covid-19 pandemic has not only led to social, economic and political changes but also to spontaneous and creative phenomena. Examples include pop-up bicycle paths, which were swiftly implemented by city councils and some of which are expected to remain in place in the long term and beyond the pandemic, or the new forms of hybrid or even fully remote work, whose changes in the world of work are having an impact.

The completed cycle of horizon scanning aims to provide suggestions for future topics of relevance for environmental policy-making. It also wants to show scope for action and give indications of the extent to which the work of the UBA and BMUV could change under the influence of these new future topics.

1.2 Topic identification and genesis: Avoiding the Corona bias

A forward-looking environmental policy is informed about emerging developments and issues. It recognises likely or possible environmental effects, it deals with these emerging issues at department level early on and also initiates discourses outside the department about their environmental implications. The aim is to act proactively before environmental problems emerge or arise on a larger scale and to proactively seize opportunities for the benefit of the environment as early as possible. A forward-looking environmental policy allows greater scope for action: on the one hand, through sufficient lead time, which enables action at an earlier stage, and on the other hand, also through the supposedly less difficult handling of just emerging future issues that are (still) outside the public interest and therefore could generate less public and political pressure to act. Especially in the case of topics that are shaped within the framework of socio-technical innovation processes, early attention for environmental policy provides the opportunity to shape the innovation

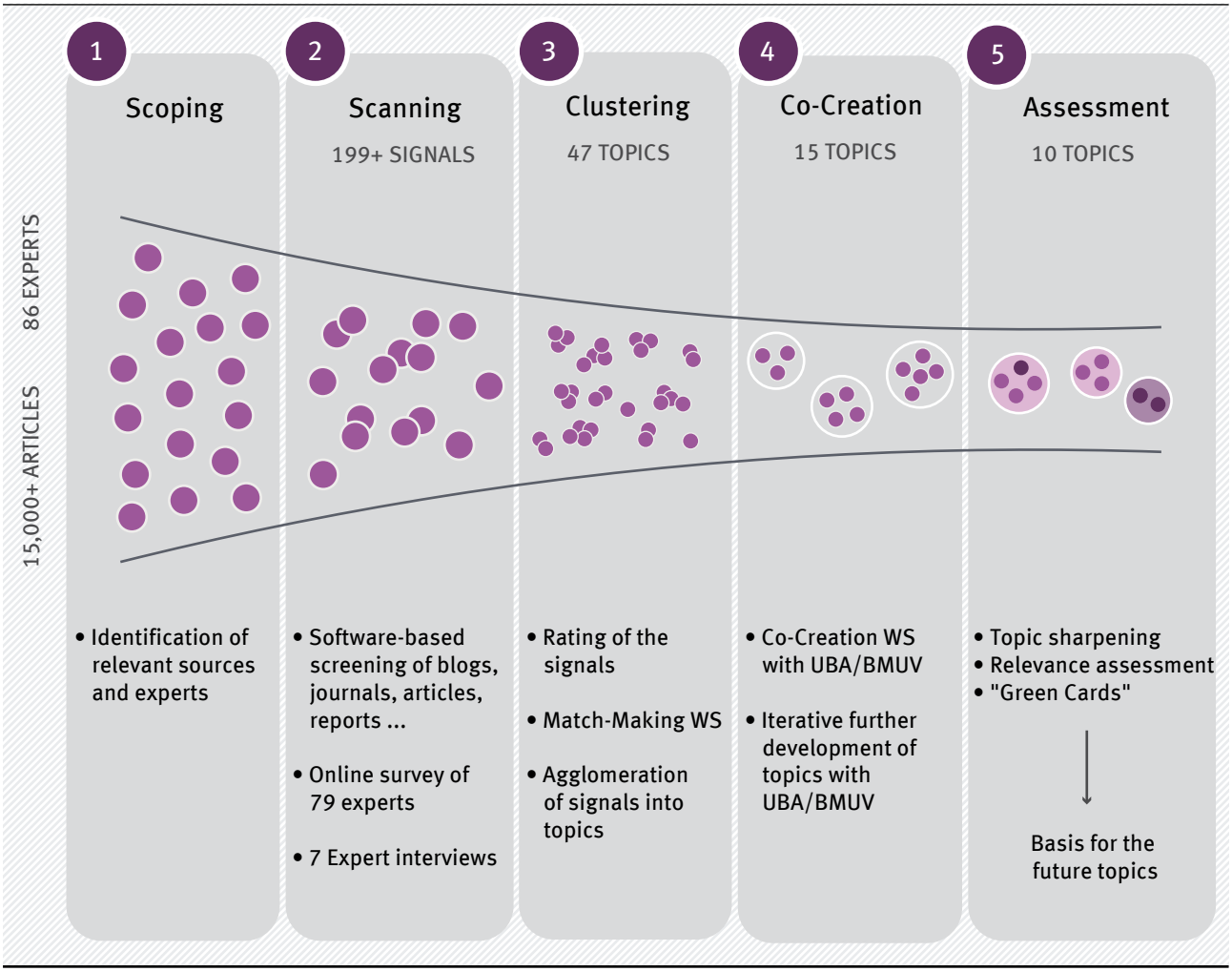
processes sustainably from the outset and together with the people and organisations involved.

The now completed second horizon scanning cycle for the UBA and BMUV is intended to support the goals of forward-looking environmental policy through early identification of environmentally relevant and emerging issues. With the emergence of the Covid-19 pandemic, this initially seemed more difficult. Many of the issues identified in the process were influenced by the Covid-19 pandemic in that they were reinforced or emerged for the first time through Covid 19-related developments. However, the aim was to avoid working on topics that only developed relevance in the context of the pandemic but not beyond. The aim was to achieve a selection of topics that was as diverse as possible and that could be linked to the work in the UBA and BMUV. To this end, the selection criteria for the choice of topics were adapted: In addition to the usual criteria of **novelty** as well as **relevance to the environment and environment policies of UBA and BMUV**, topics were to be identified that were perhaps already known or relevant to the environment, but **whose development** took a **new course due to the occurrence of the Covid-19 pandemic**. It was important to examine whether these topics would also be of importance to the UBA and BMUV regardless of the course and duration of the pandemic.

Reflection on the impact of the pandemic on the project affected the project's entire process: First, a continuous review and adaptation of sources took

Figure 01

Current horizon scanning process



Source: Own diagram

place throughout the horizon scanning cycle (see Figure 1). Daily media in particular focused their coverage on the developments surrounding the Covid-19 pandemic so that a disproportionately large number of identified articles dealt with topics related to Corona. As early as the scoping stage (first step), importance was therefore attached to being able to consider as wide a variety of sources as possible in the software-supported scanning phase.

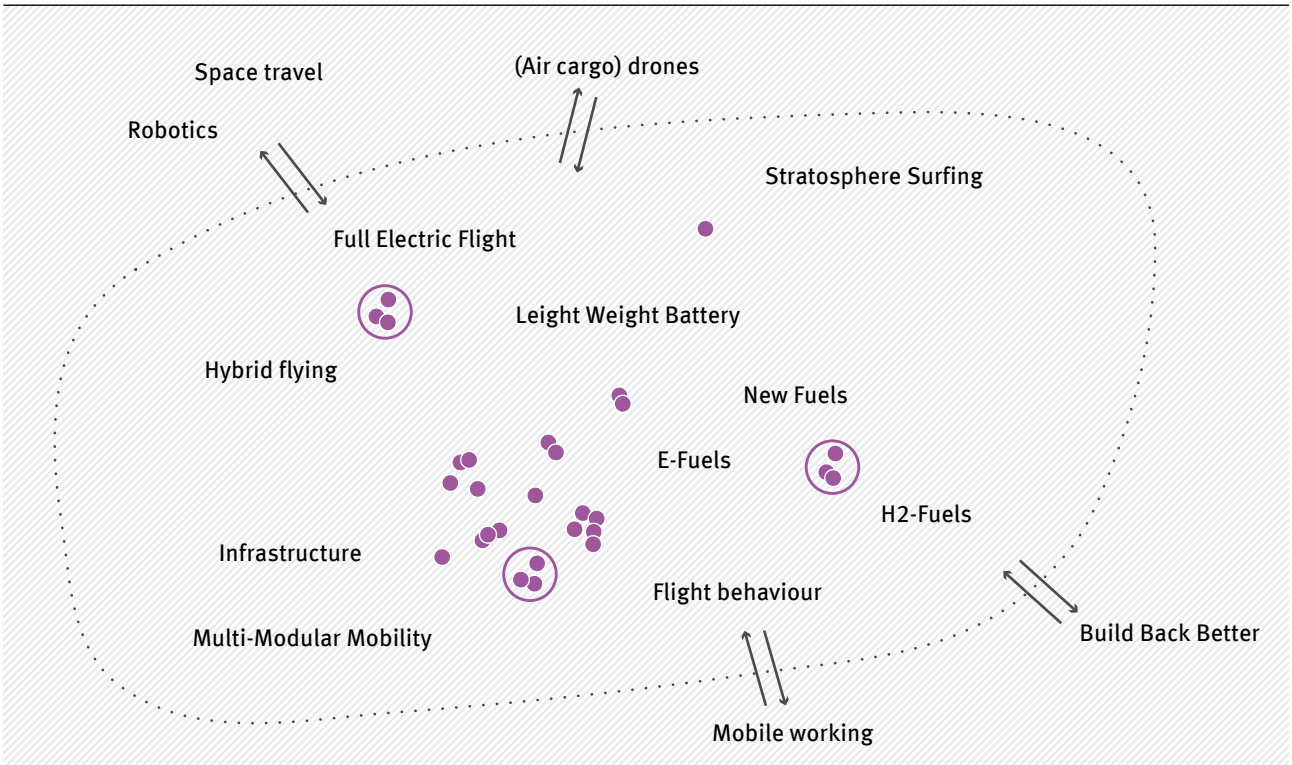
The actual scanning phase (second step) was, as in the previous process, a combination of software-based analysis of online content and consideration of expert-based knowledge through surveys and interviews. In aggregating the findings from the different sources, a total of 199 signals were identified, which were grouped into 47 topics in a clustering (third step) (for an example see Figure 2). This already showed the diversity of content, which is ultimately also illustrated by the ten topics published here. However, it also became apparent that many of the identified signals in the context of the Covid-19 pandemic had a connection to digital topics – unsurprisingly so, since digitalisation gained momentum through the pandemic.

An important step of the process in this cycle and against the background of the ongoing Covid-19 pandemic was the actual generation of topics from the identified topic clusters. Here, a co-creation approach (fourth step) was chosen. A workshop was conducted in order to establish a shared understanding of the themes, identify cross-references and avoid redundancies as well as contradictions, especially with regard to the topics related to Covid-19. This step resulted in 15 topics that were considered important for the subsequent assessment (see Figure 3).

Last but not least, an assessment was conducted, i.e. a reflection as well as a qualitative evaluation of the topics (step 5), meaning that they were assessed with regard to their novelty and relevance for the UBA and BMUV. A special focus was placed on achieving a

Figure 02

From signal to topic using the example of more climate-friendly flying



Source: Own illustration

balanced mix of topics. Four categories of topics were formed for the assessment:

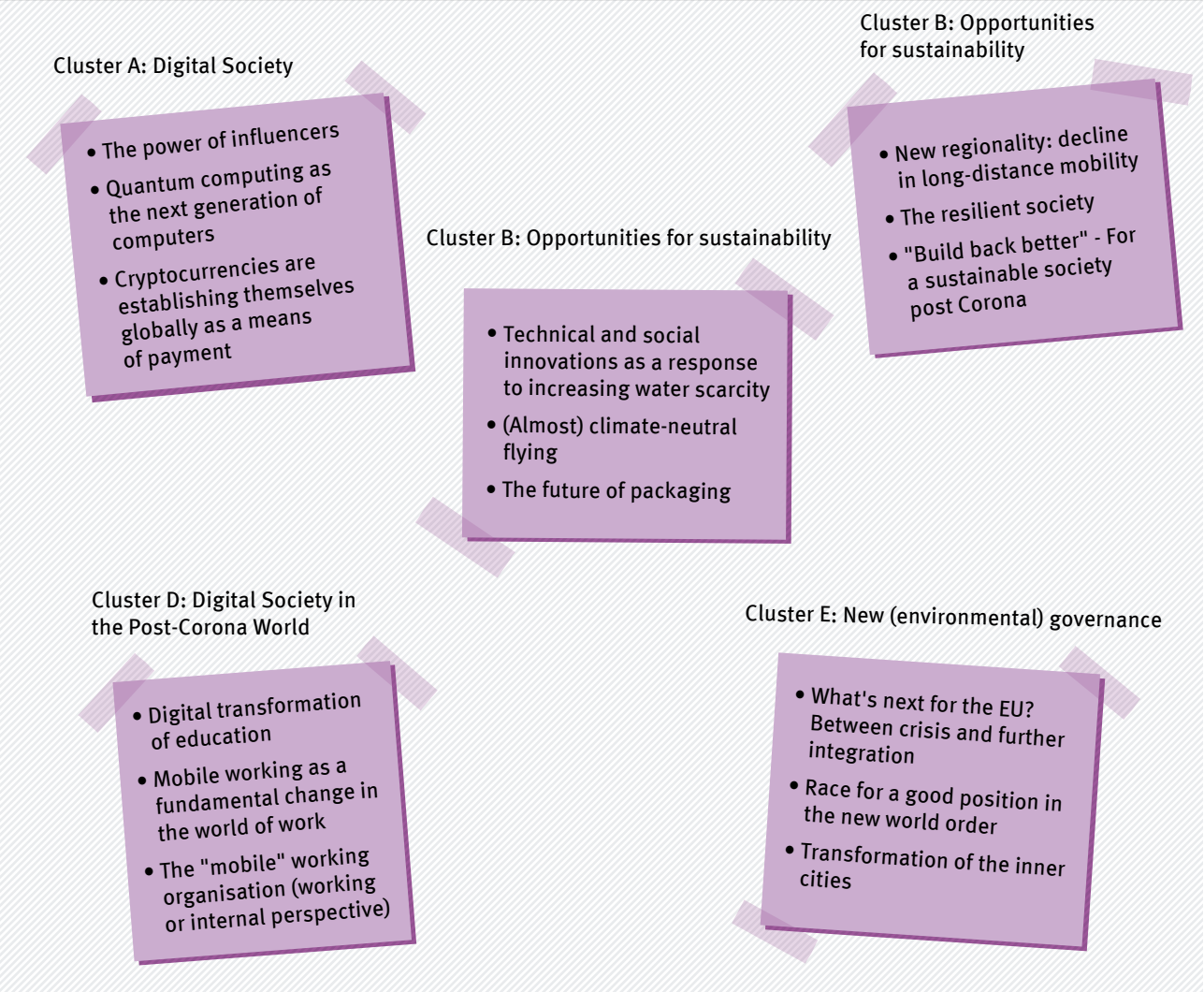
- Some developments only emerged through Corona, but have **no significance beyond** the pandemic. These had to be identified; however, they will not be elaborated further.
- Some developments came up through Corona and have **longer-term significance** for our society and the environment. These needed to be identified and worked on further.
- Already known topics were given a **new relevance** because of Corona. This means there were new topics and topics that had to be looked at in a new light.
- Some developments with an environmental impact occurred independently of Corona. These also needed to be identified and addressed.

The ten topics presented in this report are the result of the assessment:

1. Quantum computing as the next generation of computers
2. Cryptocurrencies are gaining global acceptance as a digital currency
3. Technological innovations on the way to climate-friendly aviation

Figure 03

The topic clusters in the assessment workshop

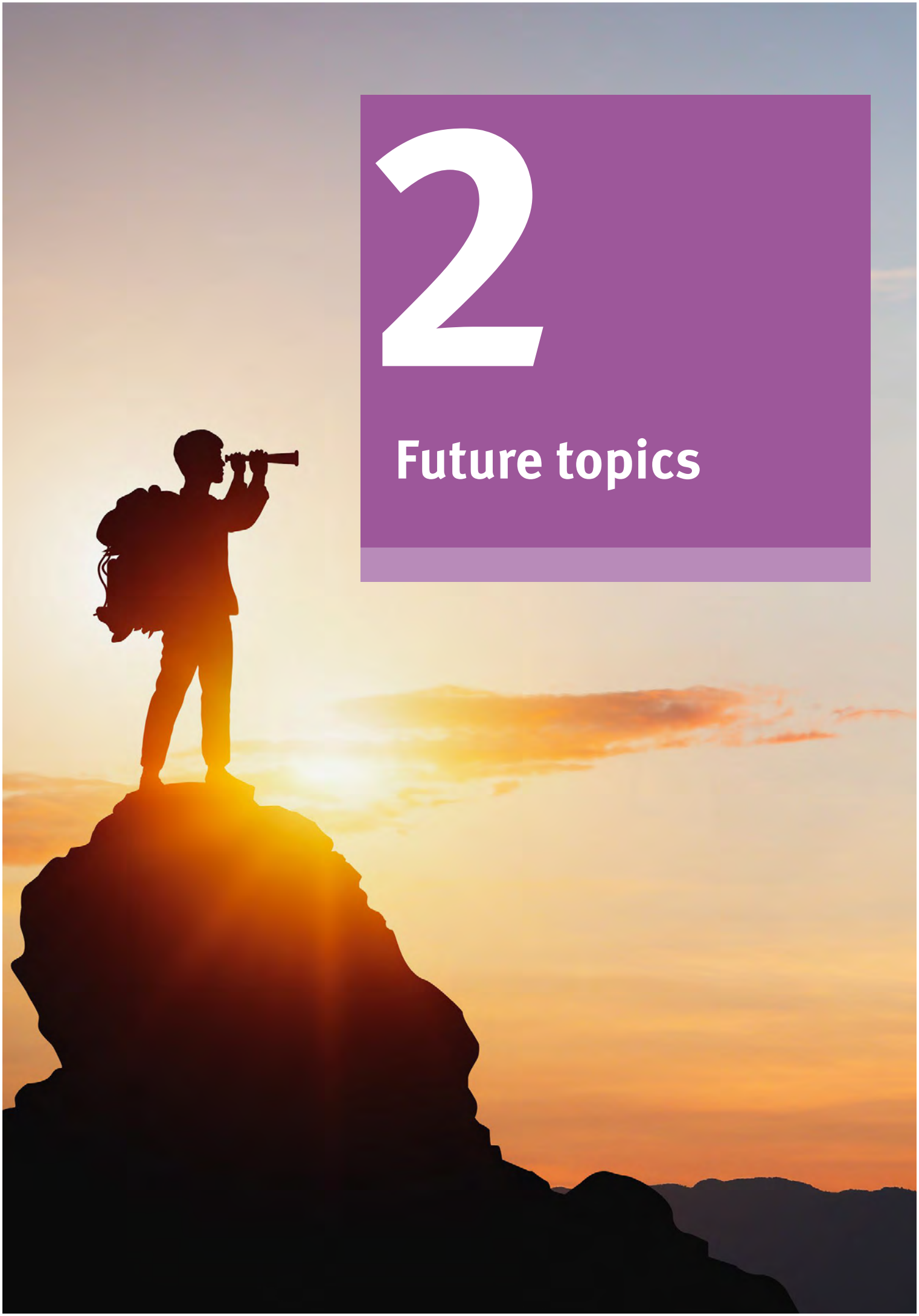


Source: Own illustration

4. New regionality
5. Resilience as the basis of a sustainable society
6. Mobile work, mobile workers and mobile organisations
7. Growing through crises: The EU's changing scope for action
8. World (dis)order
9. Opinion forming in the digital age
10. The future of city centres

Following the step-by-step horizon scanning cycle, the selected topics were elaborated in more detail. For each topic, literature research and source analyses were conducted in order to present the topics and their individual environmentally relevant aspects in a well-founded manner. As a result, the report provides an overview of ten future environmental policy topics as well as an initial assessment of possible environmental impacts and first recommendations for additional work in the UBA and BMUV. Furthermore, the future topics presented here can be a basis for further, scientific analyses. Given that no recommendations for environmental policy action are yet available, more in-depth analyses can provide more comprehensive and even more concrete clues regarding scope for action. This can also be done using other methods of strategic foresight: Trend analyses can be used to examine future issues in greater depth and describe them in terms of their emerging direct and indirect environmental impacts. Scenario studies, on the other hand, support the elaboration of future, alternative possibilities for development and narrow down the current scope for action.

However, this report also offers the interested public the opportunity to obtain information and suggestions for further thinking on emerging future topics with environmental relevance beyond the circle of actors in the UBA and BMUV.



2

Future topics

2 Future topics of the second horizon scanning cycle

The future topics presented below are the results of the second cycle of horizon scanning in the UBA and BMUV, which was carried out in 2020 and 2021. A comparable process, carried out in the same period on behalf of another institution, would certainly have led to different results. That is why the topics listed here are to be understood as a selection that in no way claims to be complete or superior with regard to other compilations. Rather, they are future topics and emerging issues that were considered relevant for the work of the UBA and BMUV by those involved in the process.

The topics presented are deliberately brief in order to do justice to the diversity of topics. In-depth analyses of selected topics may be the subject of future research projects (see above).

The description of the future issues follows a uniform pattern:

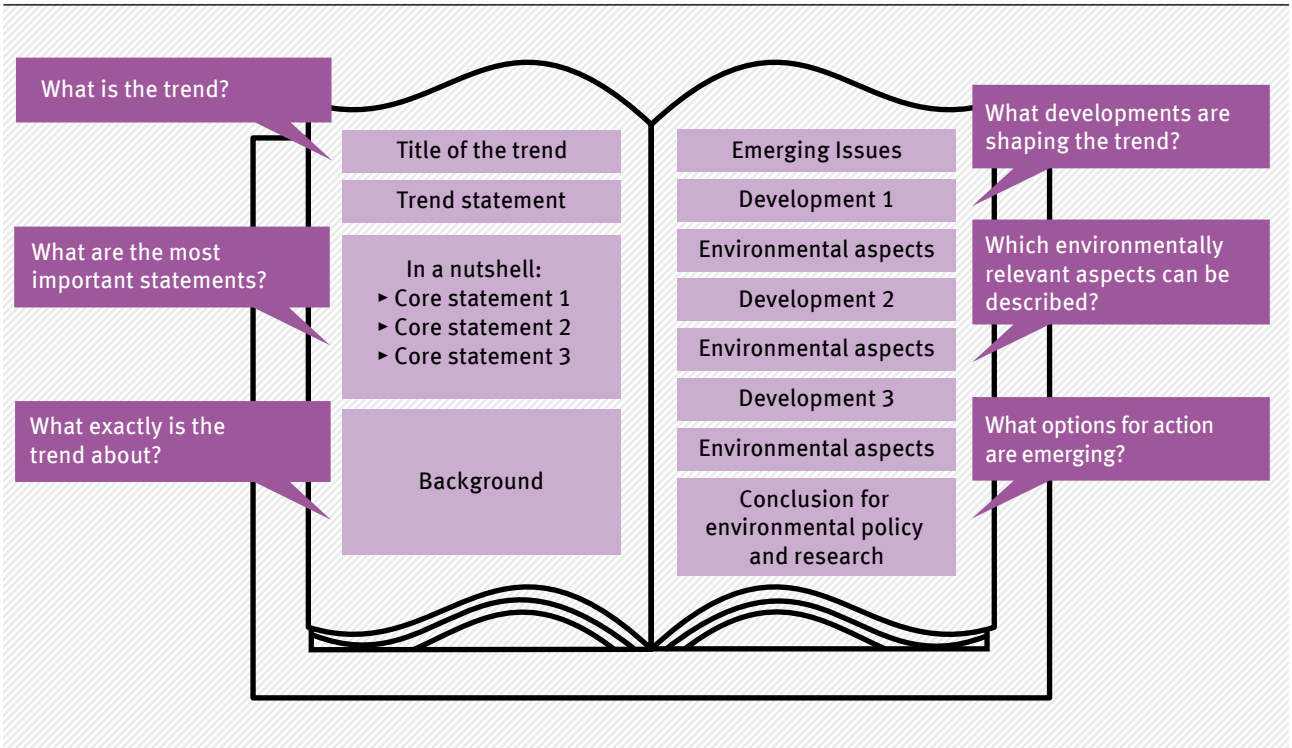
Trend: Each topic is reduced to its core statement about a possible direction of development.

In a nutshell:

- Relevant **background information** outlines the topic in rather general terms, provides examples and points out its potential and challenges.
- **Emerging issues** represent important developments within the respective trend themes and are highlighted in particular.

Figure 04

Structure of the description of future topics

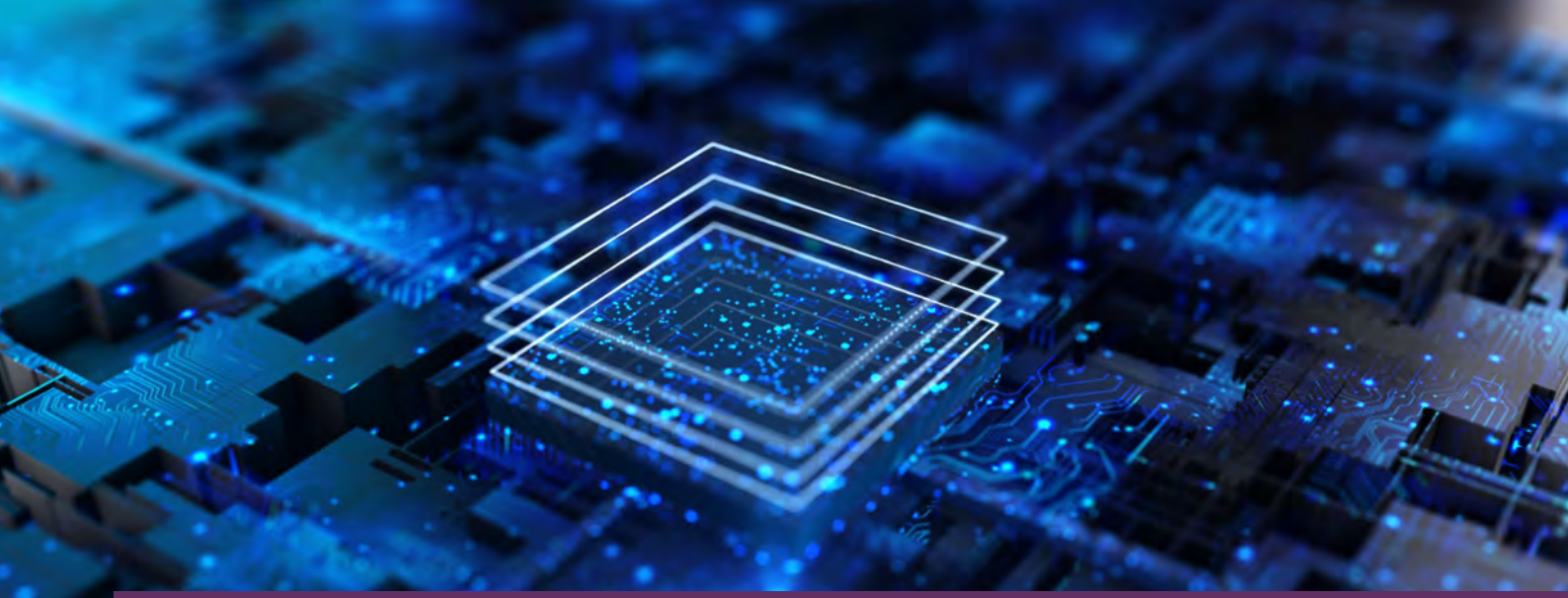


Source: Own illustration

- **Environmental aspects** are presented in conclusion in order to elaborate the relevance for the UBA and BMUV. An in-depth analysis of the negative and positive effects on the environment is not the subject of this report.

An outlook (see Chapter 3) outlines the first **recommendations for action** already identified for individual topics and presents the extent to which horizon scanning can contribute to a forward-looking, design-oriented environmental policy as a learning process for the UBA and BMUV.

The sources used in the respective chapters are listed at the end of the report. They substantiate the statements made and contain further information.



2.1 Quantum computing as the next generation of computers

Trend: Quantum computers are expected to enable new forms of problem solving in the future. Quantum computers are able to perform computing steps in parallel (instead of one after the other) and thus solve complex problems – such as the optimisation of climate models and climate protection strategies – that conventional computers are not capable of.

Emerging Issues:

- (Natural) scientific simulations
- Decarbonisation of the energy system
- Solving optimisation problems in industry

In a nutshell:

- In principle, quantum computers are expected to help solve complex problems in the future, which conventional computers either cannot do or only manage to do requiring a lot of computing effort and time. The theoretical development of quantum computers is currently being flanked by the construction of the first hardware platforms.

- Quantum computers, or rather their hardware platforms and software applications, are currently being developed exclusively to solve specific problems. Many applications of quantum computers are currently being developed. Applications with environmental relevance include (natural) scientific simulation in the context of materials research, increasing energy and resource efficiency by controlling complex networks, and optimising processes in industry.

- The production and operation of quantum computers is associated with direct environmental impacts, for example through high energy requirements as some hardware platforms need to be cooled considerably. Indirect environmental impacts arise in the various fields of application through the problem-solving capabilities of quantum computers, e.g. in the form of energy and emission savings (especially of CO_2). Quantum computers could, for example, develop solutions for how to better manage vehicle fleets, thereby improving traffic flow or better managing parking needs. However, improved efficiency may lead to rebound effects, which could offset the environmental benefits of quantum computing.

Background:

Quantum computing is currently a much-discussed technology of the future. Although the first applications have already been realised, a comprehensive use of quantum computers, for example in industry, has not yet taken place. Currently, the transition from basic research to applied research occurs (Federal Office for

Information Security, p. 17). Since around 2014, it has been possible to use quantum computers via cloud-based access (Ausschuss Digitale Agenda 2018, p. 10). The company IBM, for example, offers such cloud-based access for research, development, application, education and companies.[2] Further developments and simplifications are expected in the coming years (Eder 2021). Quantum computers do not currently work independently, but are linked to conventional computers, i.e. they can solve sub-problems for which conventional computers are not suitable (Heimisch-Röcker and Müller-Markus 2020). Whether and to what extent quantum computers will one day completely replace conventional computers and establish themselves as a new standard cannot be reliably answered, as many details are still unclear (Dyakonov 2018).

Theoretical and technical basics

In contrast to established computers, quantum computers have a completely different mode of operation, so that they can perform computing operations simultaneously – instead of only one after the other like conventional computers. This is made possible by two properties of qubits[3]: superposition and quantum entanglement. Superposition means that instead of the two states 0 or 1 in conventional bits, both states can be assumed simultaneously by qubits. The entanglement of qubits allows two or more qubits to be connected to each other, making it possible to perform complex computing operations simultaneously (Enzweiler et al. 2018; Federal Government 2021). Conventional computers can be used universally, i.e. different problems can be solved with one device. This does not apply to quantum computers at present; rather, they are being developed to solve specific problems (Heimisch-Röcker and Müller-Markus 2020).

For the development of quantum computers, it is necessary to develop special algorithms (this is the so-called “theoretical level” of development). The application of the special algorithms can be simulated on conventional computers. In addition to the development of special algorithms, suitable hardware must be developed (the “practical level” of development), i.e. the quantum computer itself (Wilhelm-Mauch 2018).

The idea of quantum computing has existed since the early 1980s. However, it only gained attention in 1994 with the development of the so-called Shor algorithm (Dyakonov 2018) and other work that explored the question of what kind of problems quantum computers are suitable for. Examples of possible areas of application include searching unstructured databases or factorising large numbers (Enzweiler et al. 2018). Concrete areas of application are outlined later in the text under “Emerging Issues”.

Technically, quantum computers are based on controlling quantum mechanical systems, e.g. individual atoms or ions, by completely isolating them from their environment (Ausschuss Digitale Agenda 2018, p. 9). At the same time, these quantum mechanical systems must be controllable by technical intervention as well as operate error-free (Meschede 2019). To this end, two approaches are being pursued in hardware development:

1. Atomistic platforms, which use individual atoms, ions or photons as qubits, and
2. Solid-state platforms based on integrated circuits (Stollenwerk 2021, p. 11). One technical challenge is scalability (Stollenwerk 2021, p. 14 f.). Currently, the most promising solid-state platforms are superconducting circuits, which

2 https://www.ibm.com/de-de/quantum-computing
3 Quantum bits/qubits are, analogously to bits, the smallest basic unit of calculation in quantum computing.

must be operated at very low temperatures, and systems based on semiconductor technology, such as so-called quantum dots (Stollenwerk 2021, pp. 15, 16-17).

At present, it is not yet foreseeable which technical platform will one day dominate, so that different approaches are also being pursued in Germany (Filip and Leibinger 2021).

Quantum computing is an international economic and research policy priority topic

In international competition, Germany and Europe are trying to position themselves vis-à-vis the US and China and to take on a pioneering role. The research programmes are correspondingly ambitious: In the US, around 1.2 billion US dollars have been set aside for multi-year funding of quantum computing in 2020 alone (Shankland 2020); in China, funding reaches similar dimensions (Chang 2021; Garisto 2021). In the EU, a multi-billion dollar funding programme[4] was also launched (European Commission 2018), the first 20 projects of which were funded until 2021 (European Commission 2021b). It was followed in 2021 by further measures, such as the construction of a European quantum computer by the year 2023 (European Commission 2021a).

In Germany, too, interest in quantum computers is high: as early as 2018, the Federal Government took an in-depth look at the topic of quantum computing (cf. public hearing on 06.06.2018). A panel of experts commissioned by the Federal Government formulated a roadmap showing which future development steps should be implemented and when. In the short term, an internationally competitive quantum computer with at least 100 qubits should be created by establishing suitable networks of cooperation (Filip and Leibinger 2021, p. 6). Such a national competence network[5] was founded on 15 June 2021, in which several collaborative projects are conducting research on quantum-based computing strategies, among other things (Polian 2021). Since 2018, the BMBF has been funding collaborative projects in Germany[6] on the basis of the programme "Quantum Technologies – From the Basics to the Market"

4 https://qt.eu
5 https://www.iaf.fraunhofer.de/de/netzwerker/KQC.html
6 https://www.quantentechnologien.de/index.html

(Federal Ministry of Education and Research [BMBF] 2018), and at the beginning of 2021, it made another approximately 2 billion euros available for funding demonstration setups (Federal Ministry of Education and Research [BMBF] 2021; Faz.net 2021).

Emerging Issues:
Since universally applicable quantum computers have not yet been realised, there is currently a debate about individual potential fields of application for quantum computers. Areas of application that could be realised in the future in the context of sustainability or with a view to environmental impacts would be, for example, (natural) scientific simulations, the contribution to decarbonisation of the energy system and the solution of optimisation problems in industry.

1. (Natural) scientific simulations
Quantum computers could be used to simulate, for example, chemical processes or material properties. For instance, researchers from ETH Zurich and Microsoft Research have succeeded in calculating the complex chemical nitrogenase reaction (Bergamin 2017). Nitrogenase is important for making nitrogen, which is essential for many biological processes, biologically available[7]. The improved understanding of such chemical reactions can help with the development of new solutions in many fields of application, not least in the fight against climate change.

In order to demonstrate the diverse possibilities, various applications are presented here as examples:

- Quantum computing makes complex physical and chemical calculations possible, for example to develop novel fertilisers or materials (Bobier et al. 2020).

- The behaviour of molecules with 50 to 150 atoms could be modelled, which would currently take a conventional computer many years. One application would be the development of optimised, highly efficient chemical catalysts, i.e. substances with which the reaction speed of chemical reactions can be improved (Bobier et al. 2020; Uminski 2020). This could revolutionise various processes that were previously very carbon-intensive – towards more climate-friendly processes. This includes, for example, the production of "green" ammonia, with a significantly lower energy input than the previous Haber-Bosch process, or a new and more efficient method for producing green hydrogen. Both processes would help to produce emission-free fuels for shipping and aviation and help to decarbonise the transport sector (Bobier et al. 2020).

- The energy-intensive production of materials can probably be optimised or replaced with quantum computing. Through the expanded simulation possibilities, optimised chemical formulas for these materials can be developed. Concrete or steel, the production of which is very energy-intensive, could possibly be replaced, which would in turn have a positive effect on the environmental balance of buildings, for example (Bobier et al. 2020; Uminski 2020). Another example is the use of improved materials in batteries. This could extend battery life by performing better (Mende and Horstmann 2021) and not decomposing. In the QuESt project (Quantum Computer Material Design for Electrochemical Energy Storage and Converters with Innovative Simulation Techniques; Mende and Horstmann 2021) research is being conducted on such new materials whose properties are simulated with the help of quantum computers. In the long term, this project aims to develop long-lasting batteries with good ranges for electromobility.

The examples show that the positive effects of quantum computing in scientific simulations are indirect, but can have a great impact.

2. Decarbonisation of the energy system
The decarbonisation of the energy system through the integration of renewable energies increases the complexity of the energy system and therefore efficiently managing the supply and demand side also becomes more challenging. The unpredictability or unreliability of sunny days and wind strengths in the operation of solar plants or wind turbines in

7 In order for nitrogen to exert its effect, e.g. for the growth of plants, it must be biologically available. A detailed explanation of the process can be found on the internet platform of the German Chemical Society (GDCh) (https://faszinationchemie.de/wissen-und-fakten/news/stickstoff-unverzichtbar-fuer-mensch-tier-und-pflanze/, retrieved on 16.09.2022).

combination with decentralised energy generation by private households require a sophisticated supply and demand management (or load management). The balancing of supply and demand with regard to the cost or price development will therefore increasingly depend on the data processing capacities of the participants (Flauger 2020). In the future, quantum computers will help to deal with this complexity (Khodaei 2020). This can be done by intelligent algorithms that evaluate huge amounts of different parameters simultaneously and establish the optimal balance between supply and demand (Flauger 2020). Electric cars, for example, would thus be charged primarily when there is a lot of electricity in the grid, and at the same time they would serve as buffer storage for days without wind (Flauger 2020).

In the heat supply of neighbourhoods, quantum computing could lead to efficient use of heat and thus energy and CO_2 savings, as various parameters on weather forecasts, usage patterns and building properties of hundreds of buildings can be calculated simultaneously and in real time, and heat energy can be distributed in a targeted and optimised manner (Flauger 2020).

3. Solving optimisation problems in industry

Automotive companies such as Volkswagen are faced with the challenge of optimising the efficiency such as the route planning problem, whether to improve supplier logistics or the vehicle guidance of autonomous vehicles (Quantum Technology and Application Consortium [QUTAC] 2021). In the future, the solution of these problems as well as the control of other complex industrial processes, e.g. fleet management and route planning or manufacturing processes, are supposed to be found with the help of the computing power of quantum computers. Quantum computers should be able to solve these and other optimisation problems because they can efficiently perform much more complex calculations.

In logistics, quantum computing can be used to calculate the fastest route for vehicles, taking into account a huge number of real-time data points about traffic jams and the like (Liscouski 2021). This allows traffic jams to be avoided and fuel and CO_2 to be saved. The optimal management of aircraft or vehicle fleets with little downtime or detours can also be achieved through fast and complex calculations, thus reducing environmental impacts in terms of energy or space consumption, for example for parking areas.

If manufacturing processes in industry are optimised through quantum computing and redundant sub-processes are avoided, it can lead to energy, material and thus CO_2 savings in the industry, i.e. to positive effects for the environment (Quantum Technology and Application Consortium [QUTAC] 2021). At the same time, optimisation of processes always harbours the potential (or the risk) that production capacities are increased or logistics services expanded – and thus environmental benefits fall victim to the

rebound effect. Minimising this risk could be the task of a forward-looking environmental policy.

Conclusion for environmental policy and research:
Quantum computing holds potential for the future. Whether the technology can make a substantial contribution to making the world more sustainable, however, remains to be seen. At present, it can be assumed that indirect energy and emission savings (especially of CO_2) can be expected. However, the solutions discussed so far in the applications presented are only incremental improvements. In principle, it must be ensured that optimisations, e.g. of processes, do not lead to rebound effects that cancel out the environmental benefits achieved.

Direct effects of quantum computing relate primarily to the material and power consumption of the quantum computers themselves. This is because quantum computers would have to be programmed, operated and monitored by conventional computers, thus requiring a material-intensive surrounding infrastructure. At the same time, energy is required for cooling and generating data (Hossenfelder 2019).

The entrepreneurial Global Future Council on Quantum Computing concluded that significant energy savings can be achieved because quantum computing can solve large-scale computational problems with a fraction of the energy consumed by today's supercomputers (Global Future Council on Quantum Computing 2020).

2.2 Cryptocurrencies are gaining global acceptance as a digital currency

Trend: Many cryptocurrencies such as Bitcoin are developing very dynamically, and more and more companies as well as (digital) payment service providers are accepting them as currency equivalents.

Emerging Issues:

- Changing relationship between environmentally harmful and sustainable cryptocurrencies
- Stablecoins with sustainable value anchor in the experimental stage
- Cryptocurrencies are increasingly establishing themselves as a digital means of payment

In a nutshell:

- With the enormous growth in value of Bitcoin, Ethereum and Co., cryptocurrencies have developed in recent years from an experiment in the creation of independent, digital alternative currencies to a speculative object. The ongoing speculative hype and the media attention attached to it, as well as the intensive debate on cryptocurrencies by science, business, politics and investors, are driving further technical developments, the improvement of the eco-balance of digital currencies and the creation of state legal frameworks. In the medium term, this could lead to cryptocurrencies establishing themselves as (state-) approved digital currencies on a global level.
- From an environmental perspective, the energy consumption of traditional and currently dominant cryptocurrencies such as Bitcoin is particularly problematic. The mining of cryptocurrencies also generates large amounts of electronic waste, for which there are hardly any established recycling cycles. Potential for improving the ecological footprint lies, for example, in the use of renewable energies for their operation.
- Cryptocurrencies can be used for various sustainable purposes, e.g. to promote the development of renewable energies or to monitor supply chains. There are also use cases that may require environmental regulation, such as the use of cryptocurrencies in the metaverse[8], when trading in (virtual) land, real estate or works of art.

Background:

Cryptocurrencies are digital asset certificates that are stored in a decentralised database, usually a blockchain. They usually have no intrinsic value but represent a perceived value. In theory, they fulfil the typical functions of a currency. These include the

8 The Metaverse is conceived as a virtual space in which elements of the virtual and real worlds coexist or are interconnected, and in which the people of the future can communicate and interact with each other.

function as a medium of exchange, the function as a unit of account and the function as a store of value. Already today, cryptocurrencies can be used as digital means of payment on many platforms, such as the food delivery service Lieferando.

Cryptocurrencies are peer-to-peer currencies. This means that they are not issued by a central authority or controlling body, such as a central bank, like state currencies, but are "mined" decentrally – as it is called in technical jargon. In the case of the first and most widespread cryptocurrency, Bitcoin, the mining consists of solving complex mathematical problems. For each correct solution, a few bitcoins are paid out. A total of approximately 21 million Bitcoins can be mined. This limit is due to the algorithm behind the Bitcoin and does not apply to cryptocurrencies in general. So far, about 80% of the maximum Bitcoin mass has been mined. In addition to access software, powerful hardware is a fundamental prerequisite for mining cryptocurrencies. This is almost exclusively affordable by professional players whose business model is aimed at mining cryptocurrencies.

The mined Bitcoins, like all cryptocurrencies, can be traded. This enables citizens, who are usually not involved in the complex mining process, to access such digital currencies. In Germany, the most widespread cryptocurrencies as well as crypto-ETNs[9] are traded via trading platforms such as eToro[10], TradeRepublic[11] or Bison[12].

Flood of cryptocurrencies and speculative object

Since the introduction of the Bitcoin in 2009, cryptocurrencies have undergone a very dynamic development in value and have become an object of speculation for many investors. Not least due to this hype, more and more cryptocurrencies are being brought onto the market. The number of available cryptocurrencies has more than quadrupled in the past five years. While 1,353 cryptocurrencies were available in December 2017, 10,894 different cryptocurrencies could be obtained in July 2022 (Statista GmbH 2022). The two most important and widespread cryptocurrencies include the already mentioned Bitcoin with a market capitalisation of approx. 890 billion US dollars and Ethereum with 378 billion US dollars (CoinMarketCap 2022; as of 01.10.2021).

The "classic" cryptocurrencies such as Bitcoin and Ethereum belong to the so-called non-backend cryptocurrencies and do not have a stabilising value anchor with which they are secured, for example gold. This makes them very volatile, which is why they can only be used as a regular means of payment to a limited extent. Stablecoins, which first appeared in 2014, are considered the second wave of cryptocurrencies. Unlike Bitcoin and the like, these are linked to a fixed asset or covered by it.

Emerging Issues:

The current discourse on whether cryptocurrencies will become established as a global means of payment contains various aspects of environmental relevance: from the optimisation of energy-intensive mining processes to leaving the experimental stage of stablecoins to a development in which cryptocurrencies may become a larger part of global payments.

1. Changed relationship between environmentally harmful and sustainable cryptocurrencies

The discourse on environmental and sustainability aspects of cryptocurrencies has long been dominated by the bad image of Bitcoin, the dominant and most widespread cryptocurrency, and the high energy consumption of its hardware, which is used for "crypto-mining". For Bitcoin, the University of Cambridge publishes the "Cambridge Bitcoin Electricity Consumption Index (CBECI)", a regularly updated estimate of energy consumption, which is currently at around 102 terawatt hours (Twh) annually (Cambridge Centre for Alternative Finance [CCAF] 2022a; as of October 2021). This is close to the energy consumption of the Netherlands (110.7 Twh/a) or about 75% of the global gold industry's consumption of 131 Twh/a (Cambridge Centre for Alternative Finance [CCAF] 2022b). This high energy consumption leads to enormous amounts of greenhouse gas emissions and thus fuels climate change. In terms of life cycle assessment, the use phase, i.e. the electricity consumption for mining, plays a major role, accounting for 98% of the

9 Exchange-traded notes (ETNs) are exchange-traded bearer bonds that replicate the performance of an underlying asset on a 1:1 basis.
10 www.etoro.com
11 www.traderepublic.com
12 https://bisonapp.com

emissions (Köhler and Pizol 2019). The level of greenhouse gas emissions results in particular from the region in which the mining is carried out, or the prevailing electricity mix there. If the electricity mix is predominantly coal-based – as is the case in parts of China, the current hotspot of Bitcoin mining - greenhouse gas emissions are high; if the electricity is predominantly based on renewable energies, emissions are naturally much lower (Köhler and Pizol 2019).

With regard to the environmental impact of cryptocurrencies, the focus has so far been on energy consumption. It is important to know that the life cycle assessments available so far still have some uncertainties regarding the assumptions made, which should be addressed in future research: This concerns, for example, the actual mining location and details of the equipment used by the miners, i.e. the hardware (Köhler and Pizol 2019). However, there is no question that cryptocurrencies as a whole are very energy-intensive.

In the third benchmark study on crypto-assets by the Cambridge Center for Alternative Finance (Blandin et al. 2020), the share of renewables used to mine cryptocurrencies such as Bitcoin and Ethereum is estimated at around 39%. This share could increase due to the ban on trading cryptocurrencies in China introduced in September 2021 (Root 2021). Up to now, China has been the largest mining location worldwide, so that a migration of miners to countries with cleaner energy production, for example Norway, could positively influence the eco-balance of cryptocurrencies. One thing is certain: in the future, a shift to mining regions, where electricity is generated (more) cheaply and through renewable energies, can lead to a significant reduction of the CO_2 footprint of cryptocurrencies (Köhler and Pizol 2019). However, the opposite scenario, meaning a pull towards even cheaper fossil electricity, is also possible, as miners usually follow the cheapest electricity price.

Even though the production of the hardware used for mining is almost negligible in terms of the CO_2 footprint (Köhler and Pizol 2019), the generation of electronic waste at the end of the use phase is an increasing and so far often neglected problem. Approximately 272 g of electronic waste are produced per Bitcoin transaction. This is about 30,700 tonnes annually, as much as is produced in the Netherlands in the form of small IT and telecommunication devices in the same period (Haase 2021; Vries and Stoll 2021). The electronic waste is mainly produced because the hardware for mining, specifically the ASIC microchips, has to be kept up to date in order to be able to mine profitably with it (Vries and Stoll 2021). The average lifespan of microchips is just over one year.

Electronic waste is particularly environmentally relevant because of very low recycling rates at only 17.4% worldwide and the containing toxic chemicals and heavy metals lead to pollution of air, water and soil if not disposed of properly. Environmental policy should therefore 1.) raise awareness of the electronic waste problem associated with Bitcoin and 2.) promote and control proper recycling at the local level (Vries and Stoll 2021).

In addition to Bitcoin with the negative environmental impacts described above, there are more than 350 other so-called PoS cryptocurrencies (PoS from *Proof of Stake*) on the market whose environmental balance sheet is completely different in terms of electricity consumption and electronic waste. PoS as a consensus mechanism does not require energy-intensive mining and therefore saves energy compared to previously discussed cryptocurrencies. The PoS-based currency “Nano”, for example, consumes only a fraction – about one ten-thousandth – of the KWh used for Bitcoin. Moreover, PoS-based cryptocurrencies do not require

ultra-specific and short-lived hardware components – an ordinary PC or laptop with access to the internet is sufficient as a working tool (Vries and Stoll 2021).

If these currencies were to become established, the problem of huge amounts of electronic waste and the energy hunger of cryptocurrencies like Bitcoin would be largely solved (Vries and Stoll 2021). To promote such a development, environmental policy could look into introducing a CO_2 tax on cryptocurrencies. It will then become apparent whether the energy savings that may occur through the use of cryptocurrencies or a blockchain in certain cross-sector fields of application make the tax acceptable for the users of inefficient cryptocurrency technology (Sedlmeir et al. 2020).

2. Stablecoins with sustainable value anchor in the experimental stage

Stablecoins are cryptocurrencies that are linked to or covered by fixed assets. They are divided into three categories: commodity-linked (for example, commodities as an asset like Tether Gold XAut), fiat-linked (classic currencies like the US dollar as an asset like TrueUSD) and cryptocurrency-linked stablecoins (cryptocurrencies as an asset like the Ethereum-based DAI). In the case of stablecoins, a certain amount of, for example, gold, fiat or cryptocurrency is physically or, in the latter case, digitally deposited by issuers of the coins for each digital coin or unit of these cryptocurrencies, regardless of their respective category.

From an environmental point of view, the process of depositing, the so-called proof-of-reserve, is the advantage of stablecoins over PoW cryptocurrencies (Proof of Work (PoW), the consensus procedure used in Bitcoin mining). Energy-intensive mining is no longer necessary, at least for commodity- and fiat-linked cryptocurrencies. Instead, stablecoin issuers are responsible for outlining the storage of the relevant currency or commodity. Tether, the largest issuer of fiat-linked stablecoins by market capitalisation (Coindesk 2022), publishes data on its own website (Tether 2022). By eliminating the complicated and energy-intensive PoW processes, commodity- and fiat-linked cryptocurrencies also do not require any mining-specific hardware. This avoids generating large amounts of e electronic waste, as is the case with Bitcoin (Stamoulis 2021).

In recent years, experiments have also been conducted with stablecoins with a sustainable value anchor, which are intended to advance the energy transition or democratise emissions trading. The SolarCoin[13] is an example of this. Producers of solar energy can register on a platform and report and verify the energy they produce. For every MWh of solar power they produce, they are credited with one SolarCoin, which they can dispose of freely. The aim is to support the expansion of solar energy. Another experiment was the Climatecoin. The cryptocurrency, which is currently inactive, is an experiment by the Spanish start-up climatetrade[14]. The aim was to facilitate access to emissions trading on the basis of the cryptocurrency and to make emissions certificates easily tradable for private individuals. For this purpose, the cryptocurrency was to be backed by a currency anchor of one tonne of CO_2, which was to be covered by certificate traders (Gierow 2015).

Even though these experiments have received a certain amount of media attention with their launch, cryptocurrencies with sustainable value anchors have not been able to establish themselves on a larger scale so far. However, this could change in the future. Analogous to gold-backed cryptocurrencies, such as Tether Gold XAut, sustainably produced or renewable resources could be traded as stablecoins.

If stablecoins do not have a sustainable value anchor, but are tied to values that are unsustainable, such as oil, they could – if further distributed – have a stabilising effect on these, combined with negative environmental effects.

3. Cryptocurrencies are increasingly establishing themselves as a digital means of payment

While cryptocurrencies have so far been known in this country mainly as an object of speculation, they are already being used as a means of payment in other parts of the world. There are also various developments that indicate that cryptocurrencies will gain in importance as a means of payment globally:

13 https://solarcoin.org
14 https://climatetrade.com

Already today, bills can be paid with Bitcoin on various internet platforms, for example Lieferando or the Microsoft Store. Organisations such as Wikipedia or Greenpeace also allow Bitcoin donations. Other companies such as Tesla and PayPal, but also credit card providers, have announced that they will accept Bitcoin as a means of payment (Bücker 2021).

Moreover, the number of stationary ATMs for cryptocurrencies is rising sharply. Within one year, from 1 October 2020 to 1 October 2021, the number of such ATMs has almost tripled worldwide: from 10,791 to 28,262 (Coin ATM Radar 2022a). They are most widespread in the USA with approx. 86.5%, followed by Europe with approx. 4.5%; in Germany, there are only approx. 57 such machines so far (Coin ATM Radar 2022b; as of 3 October 2021). Bitcoin and co. can be bought and/or sold against fiat currency at said machines, transactions can be processed via a bank account, but cash deposits and withdrawals are also possible.

In September 2021, El Salvador in Central America became the first country in the world to recognise Bitcoin as an official means of payment by law, so everyday purchases and taxes can be paid with Bitcoins. However, this development is not viewed exclusively positively. According to a survey, acceptance of the “Bitcoin law” is low; 70% of Salvadorans reject it (Demmer 2021). One reason for this are the daily, sometimes very large, price fluctuations of Bitcoin, which make it a very unstable digital means of payment.

If more and more countries accept cryptocurrencies as a legal means of payment, the environmental assessment will depend on which type of cryptocurrencies will prevail. If Bitcoins are used, as in Salvador, and widely accepted by the population, the negative environmental impacts (high energy consumption etc.) will increase. The use of stablecoins with a sustainable value anchor, on the other hand, would definitely have the potential to tip the scales in favour of more sustainability if used to a large extent.

The use of cryptocurrencies as a means of payment in the digital space could also become more important in the future. The metaverse is currently being used to describe a development of such a virtual space. Since autumn 2021 at the latest, this has received a great deal of media attention due to the renaming of the Facebook group as Meta. A spread of the Metaverse could further drive the use of cryptocurrencies in the future, as things can be bought in this virtual space with cryptocurrencies: from virtual real estate to virtual clothing. However, the environmental relevance of this new application and the use of cryptocurrencies is not (yet) entirely clear.

Conclusion for environmental policy and research:
Cryptocurrencies are on the rise and there are various indications that they will become established on a large scale despite their volatile development. Depending on the cryptocurrency used, numerous existing environmental impacts, especially in relation to energy and waste issues, could increase in the future if no countermeasures are taken. Proof-of-work-based cryptocurrencies in particular are problematic because of their high energy consumption. When expanding renewable energies, cryptocurrencies and their energy requirements – whether high or moderate – should be taken into account in the future.

The calculation of environmental impacts with life cycle assessments is still incomplete in some cases and should be researched more intensively in order to make more precise and comprehensive data bases for environmental impacts available.

Cryptocurrencies also have a lot of potential and positive effects for the environment. Depending on the design of the currency, they can make supply chains more sustainable, for example, because they enable more transparency and control. When it comes to applications in the context of sustainability, the potential of cryptocurrencies is far from exhausted. Here, further research or support from practitioners could develop new applications or new variants for sustainable value anchors. Finally, policymakers themselves have the opportunity to apply cryptocurrencies and use their steering effect for sustainability via CO_2 taxation or similar instruments, although there are no pilot projects on this yet. Finally, it should be mentioned that with the hype surrounding the still rather diffuse concept of the metaverse, cryptocurrencies and their use could potentially gain greater importance.

2.3 Technological innovations on the way to climate-friendly aviation

Trend: Technological innovations, especially sustainable fuels and propulsion concepts, can help to make aviation as climate-neutral as possible.

Emerging Issues:

- Sustainable drop-in fuels
- New jet propulsion concepts
- Innovative constructions and materials

In a nutshell:

- Global aviation contributes significantly to global warming through greenhouse gas (GHG) emissions and contrail formation. In addition, the number of flights worldwide has increased sharply over the last 20 years – and forecasts predict a further increase by 2050. Most recently, the decline in air traffic caused by the Covid-19 pandemic has increased again. However, with the start of the Russian war of aggression in Ukraine, another unforeseen development has occurred that could lead to a decline in air traffic. In addition to the flight behaviour of citizens, technical innovations for climate-neutral aviation play a very important role.[15] These include, in particular, sustainable fuels and new propulsion concepts. Furthermore, innovative construction forms and designs – often in combination with new materials – are being conceived and tested.

- Various sustainable fuels and new propulsion concepts are being developed to enable custom-fit solutions for climate-neutral flying on short-, medium- and long-haul routes. The focus here is primarily on biofuels, e-fuels/power-to-liquid (PtL), electric flying and green hydrogen, which can either be converted into electricity with the help of fuel cells or burned in gas turbines. Innovative forms of construction are also being tested, which promise high efficiency gains.

- In order to make air traffic as climate-neutral as possible, it is not only necessary to reduce greenhouse gas emissions from aircraft, but also to counteract the emergence of so-called non-CO2 climate effects, as these contribute significantly to the climate impact of air traffic. New fuels and propulsion systems can contribute to this by significantly reducing emissions such as nitrogen oxides (NOX), water vapour, soot, aerosol and sulphate aerosol particles. Therefore,

15 Technical innovations are the focus of this paper. It should be noted, however, that technical innovations are only one important component among many whose application will be necessary to significantly reduce the climate impact of air traffic. This also includes non-technical solutions such as climate-optimised flight route design and the shift of air traffic to more climate-friendly modes of transport, as well as the exploitation of regulatory and economic instruments to reduce air traffic overall.

environmentally relevant aspects should be considered in the production of fuels and also in the design of aircraft.

Background:

Measured in terms of greenhouse gas emissions per passenger-kilometre, global aviation is by far the most greenhouse gas-intensive form of transport (Öko-Institut e. V. 2020; Statista GmbH 2022) and a strong driver of anthropogenic climate warming. Emissions from aviation to date currently account for about 3.5 % of the current anthropogenic climate impact (Lee et al. 2021). In addition to emitted CO_2, which is responsible for about one third of the climate impact, condensation trails and the resulting contrail cirrus as well as emissions of nitrogen oxides (NOX) and their effect on the formation of ozone or reduction of methane are significant factors. These are called non-CO_2 effects. Other non-CO_2 effects result from emissions such as nitrogen oxides, water vapour, soot, aerosol and sulphate aerosol particles. Emitted soot particles act as "condensation nuclei" for water droplets, which freeze into ice crystals and can thus form contrails in the sky. These man-made clouds have a cooling or warming effect depending on local conditions, e.g. position of the sun, ground conditions and natural cloud cover. However, research shows that the warming effect clearly outweighs the cooling effect on average (Deutsches Zentrum für Luft- und Raumfahrt e. V. [DLR] 2021).

Global increase in air traffic

At the same time, the number of flights worldwide – in the years before the Corona crisis – rose continuously and strongly. In 2019, there were approximately 47 million flights globally (Statista GmbH 2021), an increase of 26% compared to 2014. To illustrate, of the 32.6 billion tonnes of CO_2 emitted between 1940 and 2018, about half occurred in the past 20 years (Lee et al. 2021). Before the outbreak of the Covid-19 pandemic, forecasts also assumed that an even stronger increase in the number of flights was imminent, with very strong growth rates between the years 2020 and 2050 (Gössling and Humpe 2020).

It is true that air traffic has declined sharply worldwide since the beginning of the pandemic. However, surveys and assessments by industry experts expect a return to pre-crisis levels in the years 2023 to 2026 (Hader et al. 2021). Although there were many indications of this at the beginning of 2022, the severe shortage of personnel, not only as a result of redundancies but also as a result of the exodus of workers in the aviation industry, and the start of the Russian war of aggression in Ukraine marked the beginning of a development whose consequences for aviation have been difficult to predict so far. If, regardless of these presumably short-term slumps, an increase in global air traffic is generally assumed for the next decades, technical innovations will play a very important role in making aviation climate-neutral (Abel 2022).

Interaction between technical and non-technical innovations

However, it should be noted and taken into account: Technical innovations are only one important component among many whose application will be necessary to significantly reduce the climate impact of aviation (Bopst et al. 2019). This includes, in particular, non-technical solutions such as climate-optimised flight route design as well as the shift of air traffic to more climate-friendly modes of transport and the exploitation of regulatory and economic instruments to reduce air traffic overall.

Technical improvements such as more fuel-efficient engines or the use of lightweight constructions – in conjunction with higher seat occupancy rates and optimised flight routes – have already made air traffic more efficient. (Bullerdiek et al. 2020). However, in order to open up a real perspective for greenhouse gas-neutral or even climate-neutral[16] aviation, fundamental and far-reaching changes are required, for example through the use of sustainable fuels and propulsion concepts, which are the focus of the present consideration.

16 Greenhouse gas neutrality is achieved when greenhouse gas emissions are completely offset by the removal of these emissions. Climate neutrality refers to a state in which human activities have no influence on the climate system.

Emerging Issues:

The discussion about technological innovations and developments for climate-neutral aviation is very diverse and includes a wide range of approaches. Particular focus is being placed on sustainable fuels and propulsion concepts: both with regard to short- to medium-term solutions, for example through the gradual replacement of conventional jet fuel with so-called drop-in fuels, and for long-term approaches, especially on the basis of hydrogen-based and electric propulsion systems. New forms of construction and materials, for example for weight reduction, are an additional pillar on the way to climate-neutral aviation.

1. Sustainable drop-in fuels

So far, the petroleum-based jet fuel can hardly be replaced due to its high energy density and good availability, especially on medium and long distances. A central approach to reducing this dependence is the use or admixture of so-called e-fuels, which are synthesised from hydrogen and carbon dioxide. E-fuels are "drop-in-capable", i.e. they can be mixed with traditional petroluem jet fuel. For their production, water is broken down into hydrogen and oxygen by electrolysis and turned into liquid fuel by adding carbon dioxide. The carbon dioxide is filtered from the air, for example (Scheid 2020). Due to the high electricity demand for the process, it is also called "power-to-liquid" (PtL), meaning that electricity is converted or stored in the form of liquid fuels.

The prerequisites for an application on a larger scale are the availability of large quantities of renewably generated electricity or green hydrogen, i.e. hydrogen produced on the basis of renewable energies (see Emerging Issue "New jet propulsion concepts" below), as well as corresponding production capacities. These are currently only available to a very limited extent worldwide. In Germany, the world's first industrial-scale production plant for e-kerosene was opened in October 2021, which is operated by the organisation atmosfair (tagesschau.de 2021).

E-fuels can be described as greenhouse gas neutral if the CO_2 is removed from the atmosphere and renewable electricity is used for production (Hobohm et al. 2018). Such "e-kerosene" can – compared to conventional fossil jet fuel – save up to 80% of CO_2 emissions over the entire life cycle, already including the CO_2 emissions of the manufacturing plants. In addition, it is assumed that 50 to 70% of soot and particulate emissions could be avoided in the future through the appropriate design of synthetic fuels (Deutsches Zentrum für Luft- und Raumfahrt e. V. [DLR] 2020). However, it is currently assumed that

NOX emissions will remain largely at the same level (Clean Sky 2 JU and Fuel Cell and Hydrogen JU 2020).

The production of e-fuels is very energy-intensive and goes hand in hand with a high demand for electricity. There is therefore an additional demand for electricity and a high demand for full-load hours, which must be covered by additional renewable electricity generation capacities and not by surplus electricity from existing plants (Agora Verkehrswende et al. 2018). The choice of carbon dioxide source is also crucial for the environmental impact: direct air capture or biogenic industrial processes are preferable from an environmental perspective, but from a technical point of view and due to the limited capacities available so far, they are only feasible to a limited extent. A carbon dioxide source from fossil industrial processes, such as cement plants, on the other hand, risks lowering the incentive to reduce carbon dioxide in the waste gas streams, as these are now to be used for the production of e-fuels (Purr et al. 2016; Box 2020).

Another approach to reducing the use of fossil fuels in aviation is the admixture of advanced biofuels, which, in contrast to conventional biofuels, are obtained from biogenic residues and waste materials, as defined in the European Renewable Energy Directive (RED II) (NOW GmbH National Organisation Hydrogen and Fuel Cell Technology 2021). For example, with its legislative initiative "ReFuelEU Aviation", the EU Commission is working to make such advanced aviation fuels available as an alternative in the long term (European Commission 2020). Organic waste from the food industry (e.g. cooking oil) or wood residues can be used to produce biokerosene, thus avoiding competition with food production. Residues from agriculture or forestry should, however, only be used if this does not have adverse effects on biodiversity, humus balance or the nutrient cycle. Lufthansa and KLM-Air France are already using biokerosene on a trial basis in individual cases (Schlautmann 2020). However, the economic viability and especially the availability of corresponding residual materials for larger scaling are currently not given, especially for the global scale; both are also questioned in the long term (Bopst et al. 2019). In addition, there is the risk of competition and displacement mechanisms, as residues are already used in other ways for energy and materials, e.g. as animal feed, for cost reasons (Fehrenbach et al. 2019). "Conventional" biofuels of earlier generations, for which palm oil, jatropha or sugar cane are used, for example, are not to be promoted by "ReFuelEU Aviation" and play no role in aviation. As they require a very large amount of land, natural CO_2 sinks such as rainforests are often cleared for their cultivation; accordingly, they are not considered sustainable (Scheid 2020). Novel approaches, such as the use of microalgae, are also viewed critically, partly because they also require a very large amount of land. Sourcing outside Germany should be done using strict sustainability criteria and would entail additional transport costs as well as competition for electricity generation or heat production (Deutsches Zentrum für Luft- und Raumfahrt e. V. [DLR] 2016).

When blended with advanced biofuels, exhaust gases contain a lower amount of soot particles, which reduces the formation and longevity of contrails. A new study resulting from a cooperation between DLR and NASA shows that blending a 50-50 mixture with ordinary jet fuel can reduce the formation of ice crystals in contrails by up to 50%, thus reducing the climate impact (Voigt et al. 2021). The biogenic alternatives to paraffin also have a medium to high GHG reduction potential compared to conventional jet fuel, depending on the biogenic feedstock used (Deutsches Zentrum für Luft- und Raumfahrt e. V. [DLR] 2016).

2. New jet propulsion concepts

According to aireg, a lobby group for sustainable aviation fuels in Germany, especially hydrogen airplanes and all-electric airplanes are considered to have the potential to make air traffic largely climate neutral and to significantly reduce CO_2 emissions as well as non-CO_2 effects (Bullerdiek et al. 2020).

Hydrogen or hydrogen derivatives are expected to play a central role as the aircraft engine of the future. On the one hand, hydrogen can be burnt in modified gas turbine engines. On the other hand, hydrogen can be converted into electricity by means of fuel cells, whereby airplanes can be (hybrid) electrically powered. The challenge for research and development alike: Hydrogen must either be substantially cooled on board or kept liquid under high pressure. Both require a lot of energy. In addition, larger tanks are needed than for conventional jet fuel, for which space must be created on board, for example also through

completely new construction methods of aircraft and wings (Bullerdiek et al. 2020; Deutschlandfunk Kultur 2021). In addition to adapted aircraft designs, new propulsion concepts also require a modified infrastructure, for example to enable the transport of hydrogen to airports and its provision on the ground (Bullerdiek et al. 2020). Furthermore, against the backdrop of the great importance of hydrogen for the completion of the energy transition, competition for this raw material, for example with the chemical and steel industries or with heavy transport by road, could pose a challenge.

The great advantage of hydrogen aircraft over kerosene-powered aircraft is that there are no CO_2 emissions and no emissions of soot particles and aerosol precursors. If, in addition, the hydrogen is produced with the help of renewable energies, the entire process is CO_2 neutral (German Aerospace Center [DLR] 2020). It is essential that the hydrogen is produced regeneratively. However, grey hydrogen, which is produced with natural gas or coal, is currently the most common form of hydrogen. Green hydrogen produced by electrolysis, on the other hand, accounts for less than 1% of the total amount produced (International Energy Agency (IEA) 2019). Within the framework of the German government's National Hydrogen Strategy, the production of green hydrogen is to be promoted, among other things through increased cooperation with producing countries whose climatic conditions allow for a more cost-effective production of green hydrogen. Hybrid-electric propulsion systems do not produce any emissions of NOX. If the hydrogen is burned in modified gas turbines, further technological developments are needed so that NOX emissions can also be further reduced in this propulsion system. Currently, a savings potential of 50 – 80% is expected (Clean Sky 2 JU and Fuel Cell and Hydrogen JU 2020). Another factor to be observed from an environmental perspective with hydrogen-powered aircraft is the greater emission of water vapour compared to kerosene-powered airplanes, which can lead to an increased formation of condensation trails depending on the flight altitude and the weather conditions there (Deutsches Zentrum für Luft- und Raumfahrt e. V. [DLR] 2020). However, it is currently assumed that these contrails are significantly less long-lasting and have less of an impact on the climate, since both the combustion of hydrogen and its use in fuel cells do

not produce soot that can serve as a condensation nucleus (Gierens 2021). However, further research is needed at this point to determine the exact effect of hydrogen airplanes on this influencing factor.

For battery-electric flying, gas turbines and conventional jet fuel are replaced by electric motors and battery storage. It is true that there is a high overall efficiency in electric propulsion systems. However, key technical challenges are the energy density and the weight of the energy storage systems (Bullerdiek et al. 2020). According to experts, electric flying with batteries is primarily a possibility for special short and regional routes, for example in the rugged landscape of Norway without alternative rail connections (Hiller 2021), as well as for novel applications such as air taxis, delivery drones and very small aircraft. For medium-haul routes, hybrid concepts are conceivable, for example to buffer power peaks during take-off using sustainable fuels (Sustainable Aviation Fuels - SAF). The energy density of batteries that can be achieved in the medium term is considered to be too low and their weight too high for all-electric flying on medium-haul routes (Bundesverband der Deutschen Luft- und Raumfahrtindustrie e. V. [BDLI] 2020). Accordingly, a significant transformation of air traffic beyond this, driven by battery-electric flying, is considered rather speculative (Jetzke 2017). A current scenario study by Climact and the New Climate Institute on behalf of Greenpeace assumes that only about 10% of air traffic will be battery-electric in 2050 (Martin et al. 2020).

Battery-electric flying offers the advantage of being locally emission-free in operation, as no combustion takes place during operation (Deutsches Zentrum für Luft- und Raumfahrt e. V. [DLR] 2020). In addition, there are only minor conversion losses when storing electricity in batteries. However, the prerequisite for an optimised climate balance is that the batteries are charged with renewable energy, which requires an increased provision of corresponding amounts of electricity and the energy infrastructure needed for this (Federal Department of the Environment, Transport, Energy and Communications [DETEC] and Federal Office of Civil Aviation [FOCA] 2020). The production of the batteries and the availability of the necessary resources as well as the possibility of recycling at the end of the life cycle must also be included in the consideration of the environmental impact of battery-electric flying (Öko-Institut e. V. 2017).

3. Innovative constructions and materials

New types of construction and innovative materials can form another important building block for an energy transition in aviation (Bundesverband der Deutschen Luft- und Raumfahrtindustrie e. V. [BDLI] 2020). The industry giants Boeing and Airbus, for example, have come to the conclusion that design must also make an important contribution to increasing efficiency (Koenen 2021). New design and material concepts are closely interwoven with the issue of new fuels and propulsion concepts. For example, it is necessary to significantly improve air drag and lift generation and to reduce aircraft weight, e.g. through lightweight construction concepts, in order to significantly reduce the required propulsion power or fuel consumption (Bundesverband der Deutschen Luft- und Raumfahrtindustrie e. V. [BDLI] 2020). This plays a decisive role for (hybrid) electric flying, for example. Additive manufacturing processes such as 3D printing also enable new types of lightweight structures (Jetzke 2017). Innovative fibre composites, ceramics or metallic high-performance materials should also enable a more resilient structure, optimised performance and additional functionalities. New construction methods and designs also allow a significantly improved integration of the engines in order to further improve their performance. One example of this is the so-called flying wing aircraft, which can reach “completely new dimensions of aerodynamic efficiency” because the entire aircraft structure is geared towards generating lift (Bundesverband der Deutschen Luft- und Raumfahrtindustrie e. V. [BDLI] 2020, p. 7). One example is the design of the Blended Wing Body by Airbus, which promises both improved aerodynamics and the optimal accommodation of hydrogen tanks (Spaeth 2020).

Innovative designs and materials promise efficiency gains and thus a positive environmental impact. For example, efficiency advantages of up to 20% are expected with improved aerodynamics, which will save fuel and the resources required for this (Deutsches Zentrum für Luft- und Raumfahrt e. V. [DLR] 2020). In addition, airplanes should be designed to be increasingly recyclable in the long term, so that the materials used can be reintroduced into the material cycles (Bopst et al. 2019). A new generation of airplanes can therefore potentially meet more stringent climate impact requirements; short-term, however, it is equally relevant to convert and improve current aircraft models that will be used for decades to come.

Conclusion for environmental policy and research:
For more climate-friendly aviation, it is important to reduce not only CO_2 emissions but also non-CO_2 effects such as the emission of other climate-damaging pollutants like nitrogen oxides or soot particles – and thus to further counter the formation of condensation trails and contrail cirrus clouds. Alternative propulsion technologies and energy sources offer varied approaches to solutions that, in combination with new aircraft design methods, include efficiency gains. However, there is a need for further research and investment to optimise sustainable fuels and propulsion concepts, make them competitive and introduce them across the board. Critical issues here are meeting the demand for electricity from renewable energies for the production of synthetic jet fuel as well as hydrogen, preventing land-use conflicts in the case of biofuels, and the necessary reconstruction of the aircraft fleet when using hydrogen as a fuel. Other aspects such as flight management as well as infrastructure and processes on the ground should also be taken into account in a holistic improvement of the climate impact. Due to the long development cycles in this area, it is also crucial to exhaust all other policy options to avoid and replace air travel.

2.4 New regionality

Trend: Regional solutions, for example in tourism, food or other value chains, hold great potential for sustainability, resilience and higher quality of life and are increasingly in demand. Local networks increase social cohesion. The fragility of globalisation became visible during the Covid-19 pandemic and Russia's war of aggression on Ukraine, for example because international supply chains have been persistently disrupted. This has further highlighted the growing importance of the regional level.

Emerging Issues:

- Changed travel behaviour
- New forms of urban living and settlement structures
- Regionally conscious consumption

In a nutshell:

- Even before the outbreak of the Covid-19 pandemic, regionality was considered an important counter-trend to the seemingly ubiquitous globalisation. Regional products and value chains stand for climate protection, resilience and the strengthening of local economies. As a push factor, the Covid-19 pandemic has reinforced existing trends, from the consumption of local products and the use of local services to the development of innovative settlement structures.

- Regional tourism is seen as an alternative to long-distance travel as it can offer short journeys, emotional and physical security as well as environmental, social and economic sustainability. Awareness of the importance of regional consumer goods has also increased significantly during, but also before, the Covid-19 pandemic. With their consumption decisions, consumers often want to contribute to climate protection and support local value creation. An increased longing for localisation, trust and stability is also visible in connection with the (re) design of urban settlement structures and has been further strengthened by the Covid-19 pandemic. In model neighbourhoods, living, working, community and recreation more often take place locally side by side and enable a new quality of life, caused by less traffic and noise pollution as well as by a gain in space, for example for places where people can come together and for local supply.

- The new regionality holds many potentials to the benefit of the environment: less greenhouse gas emissions through fewer long-distance holiday trips, new urban concepts with less traffic and an increase in the consumption of regional food.

But regionality alone is not enough. Here, too, the type of tourism, urban development and regional food production ultimately determines whether environmental impacts are fundamentally positively influenced or problems are merely shifted elsewhere.

Background:

The Covid-19 pandemic has thrown a spotlight on the growing importance of the regional level. For example, due to international and inter-regional travel restrictions that not only led to the collapse of the global tourism industry but also to the ongoing disruption of a variety of global supply chains, functioning regional solutions suddenly came into focus. Attractive opportunities for local recreation and tourism, regional products and services or local (neighbourhood) networks as well as cooperative forms of housing and settlement promise sustainability, resilience and a higher quality of life. The organisation of this regionality is increasingly taking place digitally, even when it comes to arranging barter transactions or services in the immediate neighbourhood (see below).

Sauter and Meyer (2003) define a region[17] generally as a specific area or landscape or a particular geographical, political, economic, cultural or demographic area. This refers to spatial units that are perceived by people as something common, a common space for interaction, experience and identity. The term "regionality" is used very differently. A recent study shows that, for example, marketers of "regional" food sometimes understand a federal state as a region, then again a radius of about 100 km around the company's headquarters or a radius of 30 km that producers are away from where their products are sold (Kampffmeyer et al. 2021).

In the context of the Covid-19 pandemic, for example, the local availability of certain raw materials or goods was strongly influenced by the disruption of global supply chains. Dependence on stable supply chains is a prerequisite for security of supply in an industrialised nation. While in the context of the pandemic it was medical goods for basic and intensive care that were in short supply in Germany, especially at the beginning, in March 2020, the availability problem for semiconductor technology is now coming to the fore and leading to the re-evaluation of procurement strategies (*reshoring* and *nearshoring*) (Maihold and Mühlhöfer 2021). The pressures and developments around the pandemic containment policies have intensified and accelerated many aspects of this trend.

Emerging Issues:

The current discourse on the new regionality, which has been bolstered by the Covid-19 pandemic, is multi-faceted and characterised by great uncertainty with regard to the effects after the end of the pandemic. Nevertheless, some of the emerging issues highlighted here, such as the change in travel behaviour or the change in consumer awareness, are likely to be important for sustainable environmental policy in the future.

1. Changed travel behaviour

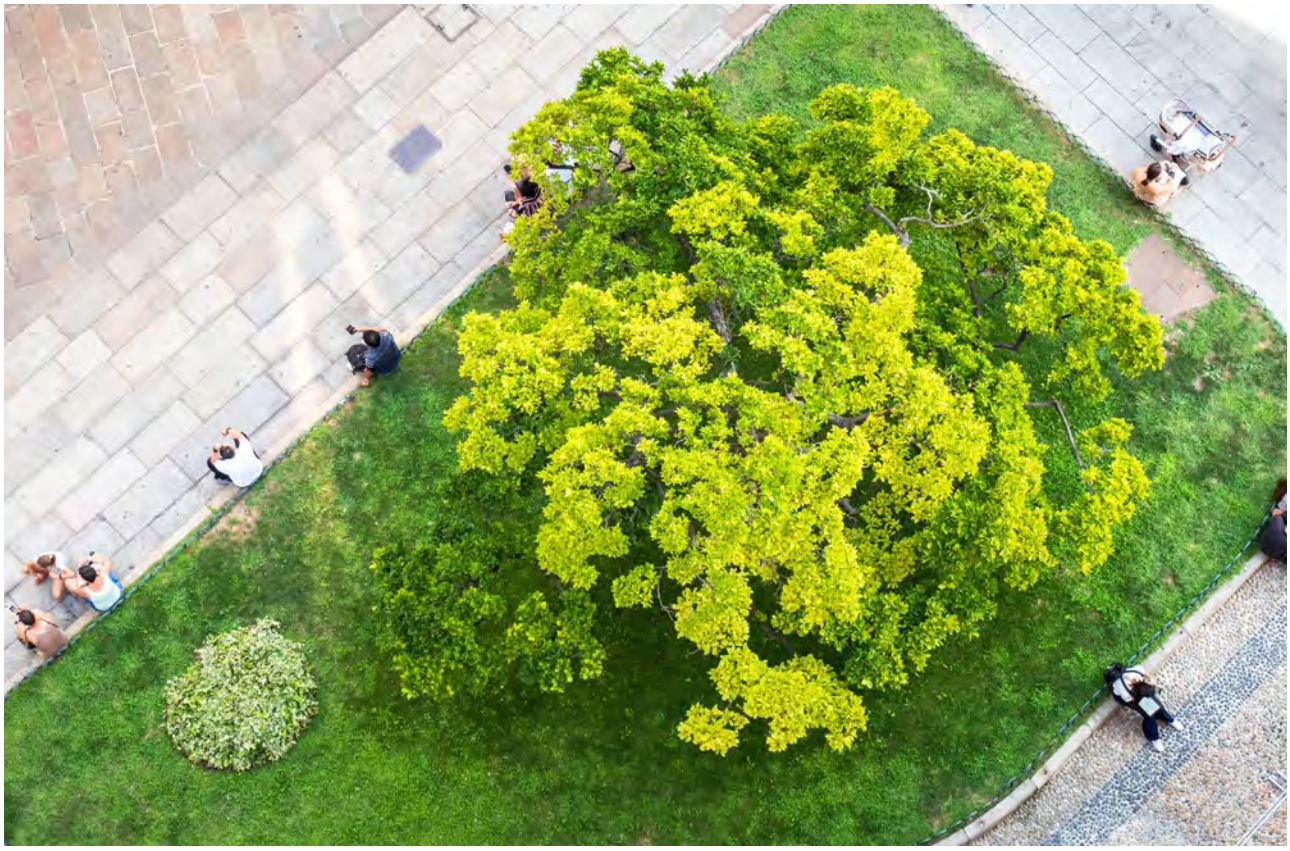
With the collapse of global travel during the Covid-19 pandemic, the question arose to what extent this development could be an impetus for a continuing decline in long-distance travel and a transformation of the travel and tourism sector. At the heart of this debate are calls for a reduction in long-distance travel in favour of regional travel and holiday destinations due to their harmfulness to the climate, and for travel as a whole to become more environmentally, socially and economically sustainable (Benz 2021a). Since the beginning of the Covid-19 pandemic, the tourism sector has been in a fundamental crisis almost everywhere in the world. However, numerous challenges had already manifested themselves in the sector before then. They include various negative local environmental impacts of "overtourism" – as illustrated by cruise tourism in Venice –, growing CO_2 emissions from air travel and increasing reservations on the part of consumers, pointedly known as "flight shame", or also increasing safety concerns. For some years now, two parallel developments have been taking place: On the one hand, the tourism industry has regularly broken its own records. Whereas in 1995 around 530 million people worldwide travelled to other countries, the figure was 1.3 billion in 2017

17 Depending on the use and purpose, regions can be defined administratively, have a landscape character or also show mixed forms of administrative and natural boundaries. In addition to natural features such as climate or water courses, cultural-historical or economic characteristics can also play an important role (Wissenschaftliche Dienste 2016).

(Eisele 2018). Holiday travel by Germans was also steadily increasing before the Covid-19 pandemic (Zwingenberger 2019). At the same time, a shift towards high-quality, individualised and sustainable tourism that conveys meaning and positive emotions could be observed. Regional tourism is therefore increasingly seen as an alternative to long-distance travel, as it can offer short journeys, emotional and physical security as well as ecological, social and economic sustainability (Kirig 2020). Local tourism organisations in Germany see the interest in regionality and locality in holidays as a strong growth trend (Heinsohn 2020). This is matched by the fact that Germany itself has consistently been by far the most popular travel destination for Germans for years and remains so; with nearby European destinations ranking behind it (Schneider 2021).

The travel restrictions experienced by tourists during the Covid-19 pandemic led to travel decisions becoming more aligned with sustainable travel principles last year, according to a survey by the European Travel Commission (ETC). These included, for example, a strong preference for destinations within the country or in neighbouring countries accessible by car, greater concern for personal well-being, air quality and human impact on the environment, and avoidance of air travel (European Travel Commission [ETC] 2021). The decrease in long-distance travel by air (or cruise ship) is positive from a climate perspective in that the associated greenhouse gas emissions decrease. However, many of the negative impacts of overtourism can persist even if only destinations and not the mode of travel change; regional destinations can also suffer from too much tourism. Regionally in Germany, the tourism footprint can mean more land use for (new) infrastructure, increased water pollution, increased waste generation and more traffic (Umweltbundesamt [UBA] 2021 and Universität der Bundeswehr München 2021).

With all the current trends towards regionality and the still lower air traffic figures (compared to the pre-Covid-19 pandemic period), it is unclear to what extent this is only a temporary trend and whether the number of long-distance trips will increase again abruptly as a rebound or successively as soon as the current pandemic situation is perceived to have ended (Deutsche Flugsicherung GmbH 2021 as well as Renn et al. 2021). Currently (as of August 2022), the number of passengers on intra-European and international flights has risen sharply again,



but is not yet at the pre-pandemic level. However, domestic air traffic continues to decline in importance (Arbeitsgemeinschaft Deutscher Verkehrsflughäfen e.V. (Flughafenverband ADV) (2022).

2. New forms of urban living and settlement structures

For some time now, urban workplaces and places of residence have been moving closer together again, motivated by the spread of the service and knowledge society, which no longer requires a distance from "dirty" factory workplaces (Maier 2020). This has long been accompanied by a new desire for stronger community ties and social interaction in cities. Uncertainties resulting from globalisation and worldwide crises thus lead to an increased longing for rootedness, trust and stability (Schreiber et al. 2017).

Even before the outbreak of the Covid-19 pandemic, model neighbourhoods showed alternatives to living on the outskirts and commuting to inner-city offices with the combination of housing, restaurants, utilities, commerce and leisure facilities; living, working, community and recreation can thus take place side by side and enable a new quality of life in cities (Beilhammer 2017). Often summarised under the catchphrase "15-minute city" and inspired by famous examples such as Barcelona's "superblocks", one of the issues is how to reclaim public urban space from car traffic and repurpose it for social interaction (Dambeck and Zuber 2020). The focus is on increasing the local quality of life, caused by less traffic and noise pollution as well as by gaining space for coming together as a community and for local supply, for example. A recent study, according to which more than 400,000 people die annually in the European Union as a result of urban air pollution, shows that cities must change in order to no longer cause health problems for their population (Beller 2020). The Covid-19 pandemic has further reinforced these developments, providing windows of opportunity for model/pilot projects such as pop-up bike lanes. Especially during the first lockdowns in 2020, people had to focus on their immediate residential environment, which suddenly became not only a place to live, but also a place to work and possibly also to study. The long-term effects of these changes on urban planning and the realisation of new concepts in the context of urban development are ambivalent even after two years of the pandemic. This is because the pandemic has reinforced some

developments that had already been apparent for some time, but it has also led to concepts that were previously considered sensible being put to the test (see also Chapter 2.8 and Chapter 2.10).

In developed cities with limited space, the need arises for a "multicoding" of urban spaces, i.e. a mix of uses, in order to provide areas for sport, play, communication, rest or recreation and to strengthen social connectedness, for example in neighbourhoods, but also in individual buildings (Just and Plößl 2021). This trend can be seen, for example, in the redesign of Berlin's Schumacher Quarter in the course of the conversion of the former Tegel Airport or in the planned new Siemensstadt in Berlin. It is about regionality in the urban district or neighbourhood, which contributes to social and economic resilience, especially in times of crisis. In addition to the effects of the Covid-19 pandemic, this development is also strongly influenced by the lack of affordable urban housing, which is to be countered by the above-mentioned examples of urban re-densification (Zukunftsinstitut GmbH 2021).

The concept of the 15-minute city, in which people can easily make most of their journeys on foot, has great potential for environmental and climate protection and for adaptation to climate change. More pedestrian-friendly urban spaces lead to a reduction in motorised individual transport, and thus to a reduction in CO_2 and nitrogen oxide emissions as

well as noise and air pollution (Tobisch 2021). If the proportion of people walking or cycling potentially increases, this may also lead to under-utilisation and thinning of public transport or reduced use and thus decline of sharing services, as occurred during the Covid-19 pandemic, e.g. in Germany, France and the USA (Beller 2020).

The consistent re-planning of cities towards a 15-minute city would lead to a redistribution of space. This means less space for moving traffic, but especially for stationary traffic, including car parks, driveways, etc. (Tobisch 2021). This offers opportunities for the reuse of these areas as green, recreational and meeting spaces. In particular, the creation of generous green spaces has many advantages from an environmental point of view. They have a cooling effect on urban spaces, especially in the summer months (Tobisch 2021). This in turn can have the effect that people are more likely to spend time outdoors than in indoor spaces artificially cooled down with energy-intensive air conditioning systems. Furthermore, green spaces help to provide opportunities for heavy rainfall to seep away – and thus make the city more resilient to climate change (Umweltbundesamt (UBA) 2019). If green spaces are managed ecologically, e.g. without pesticides and herbicides, they promote biodiversity and provide a habitat for typical urban and endangered species (Bundesamt für Naturschutz [BfN] 2019).

3. Regionally conscious consumption

When talking about increasing regional awareness, the consumption of regional products, especially food, is often understood as a central aspect. Even before the outbreak of the Covid-19 pandemic, regional products were highly popular among German consumers, who are also willing to pay higher prices for them (Handelsjournal 2019). Critical consumers have long felt increasingly alienated from modern food production and have been seeking local or regional supplies wherever possible. As a counter-movement to today's food system, in which production and consumption are largely decoupled, a need for proximity and accountability of value chains has emerged (Moschitz et al. 2018). During the Covid-19 pandemic, the demand for regional products increased even more; people not only wanted to buy local products for ecological reasons but also to support regional farms. (Federal Ministry of Food and Agriculture [BMEL] 2021).

Empirical data show that awareness of the importance of the origin and sustainability of consumer goods increased significantly during the Covid-19 pandemic; consumers want their

consumption decisions to contribute to climate protection and support local value creation (Unnikrishnan et al. 2020). Regional products are supposed to symbolise safety, identity, quality, freshness, connection, naturalness and uniqueness; corresponding characteristics therefore also play a very important role in product marketing (Penker and Payer 2005). Especially in conveying identity, security as well as ecological and economic sustainability, there is also a great intersection and interaction with regional tourism.

The trend towards consuming regional products, such as food, and using local services has advantages from an environmental point of view, such as short transport routes for goods and short journeys for holidaymakers, thus saving fuel and greenhouse gases. However, the environmental impact of the transport factor for agricultural products and food is often overestimated (Zhiyenbek et al. 2017; Benz 2021b). From an environmental point of view, the method of production is much more important than the distances that have to be covered (Deutschlandfunk 2021).

Agricultural products that are produced with a high load of pesticides or chemical fertilisers are problematic for bodies of water and biodiversity in the growing region (Deutschlandfunk 2021). Especially in meat production, the regional production conditions, i.e. the rearing of the animals and the production of the feed, play a much more important role for the climate impact than the transport from the production or processing site to the retailer.

If consumers undertake longer shopping trips by car in order to purchase (individual) goods directly from the producer in the region, there are additional and unnecessary negative environmental effects due to avoidable individual transport (Müller 2012). Bundled delivery, for example of vegetable boxes, from smaller producers to their customers via central pick-up stations has developed strongly in recent years and will probably continue to do so. Digital platforms can play an additional role in the future in order to utilise existing logistics structures, for example to integrate smaller businesses or private individuals into larger existing logistics chains. Examples of this are the platform Binghand.de or pilot projects in Bavaria, where public transport

should be used to haul parcels (Informationsdienst Wissenschaft 2021). These offers could, for example, avoid unnecessary empty runs and relieve city centres in terms of traffic. In order for regional products to have a more favourable environmental balance than, for example, imported products, both production and distribution methods would have to be made more sustainable across the board in the future.

Buying regional products at markets, via vegetable boxes, etc. also has an indirect positive effect on the environment. Through direct communication with the producer, consumers gain an understanding of production conditions and thus of their own involvement in or responsibility for local environmental damage (Müller 2012). Increased environmental awareness, in turn, is often the first step towards more personal responsibility and thus changes in behaviour, for example in consumption decisions, towards more sustainable behaviour.

Conclusion for environmental policy and research:
Especially in times of crisis, regionality promises emotional security, resilience, community and identity as well as greater sustainability. However, it does not represent a value in itself, but only makes sense in terms of sustainability if certain qualities are linked to it – e.g. environmental effects must be considered and evaluated holistically. Where

in the value chain, for example, is CO_2, waste or space saved and where do new negative effects on the environment occur and how serious are they? The analysis of environmental effects applies in particular to the production of local goods and food but also to regional tourism offers. Only in this way can the Covid-19 pandemic offer the opportunity to fundamentally transform the tourism sector, for example, and reduce its environmental impact (European Travel Commission [ETC] 2021). However, there is also the aforementioned uncertainty as to whether the effects amplified by the Covid-19 pandemic will last beyond the duration of the pandemic. This requires forward-looking, inclusive policy initiatives and corner stones.

The creation of a new urban regionality also holds great potential for sustainability, e.g. through more inner-city green and recreational spaces with all the above-mentioned positive consequences for the environment and health. In this context, it is crucial to coordinate bottom-up and top-down approaches and adapt them to the needs of the heterogeneous population, for example through close cooperation between social groups and administration, business and science (Just and Plößl 2021). And finally, an evaluation and assessment of pilot projects carried out during the Covid-19 pandemic must take place in order to be able to perpetuate positive developments.

2.5 Resilience as the basis of a sustainable society

Trend: Current crises – for example, the Russian war of aggression against Ukraine, the Covid-19 pandemic or climate change – reveal serious vulnerabilities of infrastructures, economic systems and other societal sub-sectors such as the health or education sector. Resilience is therefore increasingly becoming a basis for sustainable societies to cope with crises and equip societies for future crisis management.

Emerging Issues:

- Contributions of resilient economic systems to solving environmental and climate crises
- Resilient infrastructures as stabilising elements in supply crises
- Functioning, democratic state systems enable the emergence of resilient societies

In a nutshell:

- Against the backdrop of numerous current crises and the multitude of vulnerabilities exposed by them, the need for greater resilience in political, social and economic terms is being discussed. Resilience is described by the European Commission as the ability to withstand and overcome challenges. This includes managing transitions in a sustainable, fair and democratic way. This capacity must be actively pursued and created.

- Resilience is currently becoming an ever stronger and more comprehensive component of economic, social and ecological discourses. Particularly (environmentally) relevant in this context are resilient economic systems, which make a decisive contribution to political stability and therefore make it easier to gain acceptance for international climate and environmental policy. Furthermore, resilient infrastructures and resilient societies, which are able to deal with crises and changes at both individual and community level.

- The concept of resilience can be found in a variety of environmental and sustainability policy discourses. Although there are numerous links to environmental and sustainability policy fields of action, there is as yet no consistent understanding of the concept from which common target criteria for resilience and environmental policy can be derived.

Background:

In recent years, severe crises have greatly challenged our society: the Russian war of aggression against Ukraine, which began as early as 2014 with the annexation of Crimea, the Covid-19 pandemic, the global banking and financial crisis from 2008, the migration crisis of 2015 and 2016, and the increasingly visible climate and endangered species crisis. What these crises have in common is that both their causes and their effects are highly complex and

that they are highly interconnected on a global scale. (cf. also chapter Future EU).

Against the background of the multitude of societal vulnerabilities exposed by the polycrisis, the need for societal resilience is increasingly being discussed scientifically, politically and publicly. Even though the term resilience was used, for example, in ecology research as early as the 1970s (Marg 2016, p. 83 ff.), resilience is increasingly being recognised as an important basis for the long-term functioning of modern societies.

No clear definition of resilience

Resilience as a concept is not clearly defined both in scientific discourse and as a political goal (Kagermann et al. 2021, p. 20; Roth et al. 2021, p. 10; Rudloff 2022, p. 7 f.). Defined abstractly and broadly, resilience can be understood as a system's ability to deal with surprising, exogenous (negative) shocks while maintaining or quickly regaining its functionality and fundamental properties (absorption) to adapt in order to be prepared for future crises (adaptation), as well as to fundamentally change (transformation) when necessary (Rudloff 2022, p. 7). For this, a system needs characteristics such as anticipation, sturdiness and adaptability or flexibility and agility, which are understood as core components of resilience. Resilience is therefore a capability of a social subsystem, for example, that must be actively sought and created and that can be formed at various levels, from the individual to companies, value creation networks, national economies, political and scientific institutions, and society as a whole, but is rather distinctive in each case (Roth et al. 2021, p. 10).

Resilience as a guiding principle for political action

In this sense, the European Commission understands resilience as the ability not only to face and overcome challenges but also to enable sustainable transformations (European Commission 2020, p. 6). Building and maintaining resilience therefore includes preparatory measures for crisis management as well as measures to mitigate the consequences of crises and to adapt to changing framework conditions. Resilience is not static, but develops dynamically.

Similarly, in the further development of "Germany's Sustainable Development Strategy", the German government sees resilience as an element of the guiding principle of sustainable development, which has gained importance in the wake of the Covid-19 pandemic (Die Bundesregierung 2021, p. 30). The Covid-19 pandemic revealed vulnerabilities in public, economic and private life, which include the effects of drastic inequalities in wealth, fixation on short-term efficiency maximisation, lack of or declining trust in political and scientific institutions, and increasing susceptibility to questionable information or disinformation campaigns (Walz et al. 2022, p. 20). These and other vulnerabilities are characteristics that can amplify the negative consequences of crises and structural changes in systems. They also represent obstacles in the pursuit of long-term strategic goals (European Commission 2021a, p. 6).

Vulnerabilities, however, are contrasted by those capacities with which transformations can be driven forward and the effects of exogenous shocks can be absorbed and managed. These include, for example, political measures, a society's social capital or the innovative capacity of economic players (European Commission 2021a, p. 6 ff.).

While resilience has become a leitmotif at the political level, and in various policy areas acts beyond crisis prevention, a comprehensive operationalisation through political measures has not yet taken place (Rudloff 2022, p. 9).

Emerging Issues:

Due to the experiences of recent years, resilience has not only become a political leitmotif, but also a component of numerous discourses in business, science and society. In this context, resilient economic systems are considered particularly (environmentally) relevant, as they not only produce products and infrastructure for a sustainable society but also make a decisive contribution to social peace and thus also to political stability, which in turn is a prerequisite for pushing international climate and environmental policies through. In resilient societies, people can cope with crises and change at the individual and community level. The infrastructure in these societies is designed to be sustainable, stable and resilient at the same time and thus makes an important contribution to the resilience of society.

1. Contributions of resilient economic systems to solving environmental and climate crises

Resilience can be considered at employee, company and sector level. Even the entire economic system can be characterised by resilience (Kagermann et al. 2021, p. 21). The environmental relevance is described below with regard to the company level.

At the level of individual companies, resilience is understood as the interplay of personal or individual and corporate factors as well as environmental factors (Flüter-Hoffmann et al. 2018). Characteristics differ between companies, so that some companies can be considered more resilient than others (Roth et al. 2021). At the level of the individual company, aspects such as the diversification and transparent design of supply chains, but also more flexible production and the establishment and expansion of active risk management, including strategic foresight, are likely to play a greater role in creating or increasing resilience in the future through an environmental perspective (Kagermann et al. 2021, p. 7).

Transparent value chains can further the creation of sustainable production conditions. They provide information on resource extraction, production, transport, trade, consumption and end-of-life aspects. This in turn bolsters aspects of environmental protection and sustainability along the supply chain, for example the reduction of CO_2 emissions or water consumption (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety [BMUB] and Federal Environment Agency [UBA] 2017, p. 7).

Every company has the opportunity to strengthen resilience along its value and supply chain through its economic influence. This is based on the selection of links in the supply chain: a sustainable supply chain consists of environmentally and socially sustainable systems based, among other, on fair payment, good working conditions and the prevention or reduction of environmental pollution. The implementation of environmental protection or sustainability along the supply chain in general forms the cornerstone for the resilience of a company and its value chain. In this way, business risks can be limited, efficiency gains generated and the viable requirements of customers addressed (Jungmichel et al. 2019).

At the level of economic systems, numerous, globally interconnected supply chains are part of corporate value creation. Warehousing, which, depending on the product, leads to space requirements and costs, has been minimised over the years in order to make supply chains as efficient as possible (Kagermann et al. 2021, p. 26). Disruptions in the supply chain, such as the loss of suppliers, can lead to certain components no longer being available and production being disrupted (McKinnon 2018, p. 8).

“Green” technologies have a high demand for critical raw materials such as rare earths, lithium or cobalt. In order to be able to ensure the production of future-oriented technologies, access to these raw materials is crucial. The concept of resilience is expressed here with the term “criticality”. Among other factors, reliability in supply relationships lowers criticality (Rudloff 2022, p. 14). The increase in reliability, in turn, is strengthened by a network of transparent relationships along the value chain, as the individuals and companies involved are not only in a supply relationship but also in a risk relationship. In this respect, a value network offers the possibility to overcome shortages (Hertwig 2021).

Above all, the Covid-19 pandemic and, most recently, the Russian war of aggression against Ukraine have exposed the vulnerabilities and capabilities of individual companies, sectors, industries and, most recently, the entire economic system. One of the first generally noticeable effects in the wake of the Covid-19 pandemic – in addition to the

tense situation in intensive care units – was the interruption or disruption of a large number of international supply chains and correspondingly disrupted production and trade processes around the world, with consequences such as the lack of availability of masks or the chip shortage in the automotive industry (Walz et al. 2022, p. 7 f.).

From an environmental perspective, the Covid-19 pandemic has led to a decrease in greenhouse gas emissions. In Germany, around 739 million tonnes of greenhouse gases were released in 2020 – around 70 million tonnes or 8.7% less than in 2019 (Federal Environment Agency [UBA] and Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection [BMUV] 2021). At the same time, public funding and economic power are needed for climate investments. A study commissioned by Agora Energiewende estimates the financial requirements for public climate investments by federal, state and local governments at a total of 260 billion Euros for the period 2021–2030 (Krebs and Steitz 2021). According to calculations by Agora Energiewende, GHG reduction targets can only be achieved with a modern climate policy that focuses on expanding macroeconomic investments in climate-neutral infrastructures and technologies in the fields of energy, industry, transport, buildings and agriculture (Agora Energiewende et al. 2021).

The effects of the war in Ukraine are most evident in rising energy prices and food supply security. A deeper look reveals: The vulnerabilities that have come to light are often structural and can result in significant impediments, also due to the influence of other massive crisis developments such as climate change or regional conflicts.

Appropriate strategies are needed to strengthen the resilience of the economic system at all levels mentioned (European Commission 2021a). With regard to global supply and value chains, for example, a stronger departure from globalisation and a shift back to local value creation are possible (Liedtke et al. 2020). This correlates with efforts towards technology sovereignty (Walz et al. 2022, p. 7 f.; European Commission 2021b), i.e. the state's ability to produce and further develop technologies deemed critical (Edler et al. 2020). However, shifting value creation back to the local level entails risks, especially country-specific or local dependencies, which do not necessarily increase supply security. Therefore, security of supply should not be at the heart of an economic resilience strategy but rather

the interdependencies between different economic systems (Rudloff 2022, p. 35).

Local value creation and short transportation routes can contribute to environmental protection and sustainability in general by reducing emissions and controlling the ecologically and socially sustainable production of goods (Energieagentur Rheinland-Pfalz GmbH 2018, p. 78). In this sense, the circular economy strengthens independence from raw materials and equally reduces raw material extraction and associated negative environmental impacts (Eisenriegler 2020, p. 15). Material flows should also be regionalised and regional players should be cooperatively linked. According to Liedtke et al., resilient supply chains between such cooperative regional economies are characterised by the fact "that they can ensure the security of supply to meet basic needs even in the event of sudden changes in the framework conditions, for example due to crises" (Liedtke et al. 2020, p. 15).

Only a resilient and stable economy makes it possible to deal with systemic crises such as climate change (World Economic Forum 2021, p. 5; see also European Commission 2022). For example, sound public finances are an important basis for investment in research into environmental technologies. Simultaneously, the expansion of environmental technologies results in long-term cost savings through the avoidance of environmental damage. Between 1994 and 2014, the expansion of renewable energies in Germany prevented environmental damages of around 11.6 billion euros (Kahlenborn et al. 2019, p. 10). These savings in turn stabilise the economic system and create scope for investment.

It highlights the importance that environmental and sustainability policy remain on the political agenda. The Corona crisis has shown that the focus of environmental policy can be eclipsed by health and economic crises. There is a constant risk that environmental and sustainability policy will be pushed off the agenda by other crises (Fischedick and Schneidewind 2020, p. 4). Therefore, the current German Sustainability Strategy also emphasises at various points that political measures in response to the Corona crisis must focus on sustainability and avoid losing sight of sustainability (Die Bundesregierung 2021, p. 366).

2. Resilient infrastructures as stabilising elements in supply crises

Resilience always plays a particularly important role in the context of infrastructures if these are among the so-called "critical infrastructures". In this context, "critical" does not refer to the fact that such structures are particularly susceptible to failures etc., rather, disruptions of such infrastructures are accompanied by far-reaching to catastrophic consequences for society, the state and/or the economy.

Three critical infrastructures (ECIs) are currently identified at European level: Energy supply, transport and traffic infrastructure. Currently, the guidelines for the protection of ECIs are being reformed and in the future, eight further critical infrastructures are to be addressed: the banking and financial market system, healthcare, drinking water and sewage networks, digital infrastructures, public administration and space travel. In Germany, critical infrastructures are already being interpreted more broadly. They include information technologies, energy supply, transport and traffic, telecommunications, water and food supply, finance and insurance as well as the healthcare system (Rudloff 2022, p. 11 f.). As different as the above-mentioned infrastructure systems are in terms of their application context as well as from a technical point of view, they are united by a megatrend that is already having an effect today and will play an increasingly important role in determining the systems in the future: digitalisation.

In addition to classic threat scenarios of (critical) infrastructures – these include natural hazards (as a result of climate change), scarcity of raw materials due to international conflicts or simply unsuitable infrastructures due to wrong investment incentives – the vulnerability of decidedly digital infrastructures, for example due to cyber attacks, will play a significant role in the future. Sabotage and attacks are increasingly shifting into the digital space. For example, the FBI in the USA warned as early as spring 2016 that the digital agricultural infrastructure and smart farming systems in particular were being targeted by cyber attacks (Reuter et al. 2019). Currently, Russia's hybrid warfare, including massive cyber attacks on Ukraine's power grids, is one of the most widely communicated examples in the media (Kolvenbach 2022), but transport systems are

also becoming increasingly vulnerable with greater digitalisation (Schelewsky and Canzler 2017).

In order to protect future (critical) infrastructures with a high degree of digitalisation against vulnerability, resilience strategies are indispensable. They should address the identification of risks and weaknesses as well as the robust and precautionary system design and include absorption and adaptation approaches. The ability to measure the resilience of infrastructures is a particular focus here. Resilience can be determined on the basis of indicators that show, for example, the probability of occurrence of failure situations, the age or the degree of maintenance of specific infrastructures. The quality of the indicators and the quality of the available data play an important role in resilience assessment (Dunn, Cavelty and Prior 2013).

Measures for adapting existing digital infrastructures or the prerequisites for future digital infrastructures are diverse and must be assessed on a case-by-case basis. One possibility for increasing resilience in relation to vulnerabilities based on digitalisation that can be applied to various infrastructures are decentralised isolated networks. They have been identified as a core component of resilience in the context of digital agriculture (Reuter et al. 2019). Here, “farm data” are not stored on cloud data centres but on their own databases, which can also function without an internet connection if necessary. Data can be exchanged via computer-to-computer interfaces. In this case, the company’s ability to establish isolated networks and data exchange standards, on which all participants must agree, are essential core components. The systems can be connected to the internet, but can continue to be used in the event of a failure. A major advantage is that the system does not fail if a large, central database has been successfully attacked. However, the decentralised databases must also be protected against cyber-attacks.

The discussion on resilient infrastructures and security of supply can be exemplified by agricultural policy with regard to environmental impacts and interrelationships. The Russian war against Ukraine highlights society’s dependence on particular infrastructures or systems, such as wheat cultivation in Ukraine – a switch to sustainable infrastructures can strengthen the resilience of these systems.

In agricultural policy, the link between resilience and environmental or general sustainability considerations has already become distinct

(Rudloff 2022, p. 17). The initial focus of European agricultural policy has been expanded over time to include environmental and general sustainability-related aspects and integrated into instruments such as subsidy policy. One of the effects of global food production is the cultivation of monocultures in different regions. This form of cultivation weakens the agricultural economy, as it depends on the fertility of the soil. Despite chemical optimisation attempts, soil fertility is more resilient, productive and healthy through alternating crop rotation (Macholdt 2021, p. 13). The return to regional and seasonal agriculture aims, among other things, to promote food security for society as well as to strengthen sustainable agriculture. The understanding of resilience, which traditionally focused on ensuring food supply, has been expanded to include environmental and sustainability considerations, including avoiding consequential damage (Rudloff 2022, p. 20).

3. Functioning, democratic state systems enable the emergence of resilient societies

A resilient society is characterised by a high degree of willingness to share risks, the ability to negotiate and trust in the relevant institutions, both in an informative and in a steering role. For a resilient society, a functioning state order based on democratic principles is therefore just as necessary as civil society, voluntary commitment and the ability to debate and compromise.

In the Covid-19 pandemic, societal resilience, which had already been severely strained by the crisis experiences of previous years (see Chapter 2.7), was faced with major challenges: The question of triage in hospitals was just as unfamiliar to the population as the handling of vaccination against Covid-19 – from development to licensing to the question of compulsory vaccination. It also became clear that a.) the state does not have the sole and generally accepted sovereignty of interpretation on these issues and b.) the continued "battle of opinions" - in this case especially fought by "Covid

deniers" and "anti-vaxxers" – can lead to an erosion and delegitimisation of state/public institutions and offices.

As a crisis of global proportions and severe impacts, the Covid-19 pandemic can be seen as providing a training of sort for the challenges of dealing with the causes and consequences of climate change. In this context, resilience in the sense of flexibility and situational adaptability can mean for policymakers to forego rigid guidelines and instead also rely on community-oriented self-responsibility equipped with the necessary competencies – which must seem just as contradictory in view of the implementation of binding climate targets as the avoidance of transformation-related social inequality. In this context, it is to be expected that the capacity for societal resilience and thus for maintaining social, inclusive and democratic communities will be fed both by collective learning and competence-development processes and by the creation of permeable societal structures and variable mechanisms. In particular, however, the state itself has shown in the Covid-19 pandemic that it is capable of action and empowerment and therefore has proven competent to mitigate the (economic) consequences of the crisis.

For the state's promise of security, the emphasis on resilience means admitting that there is no such thing as one hundred per cent security or certainty: "Resilience is a changed model of security, in which the focus is less on the complete absence of dangers and more on successfully dealing with risks" (Folkers 2017, p. 11). In this way, the state becomes a dynamic risk manager, which acts by weighing up the hazards emanating from overlapping crises (polycrisis). In the process, management is typically confronted with different risks that compete with each other – currently, for example, energy supply security with foreign and security policy, climate protection or nature conservation. This means that minimising one risk often leads to other risks (Reckwitz 2020).

It is therefore obvious that strategies for strengthening resilience, such as the "German Strategy for Strengthening Resilience to Disasters" published in July 2022 (in short: Resilience Strategy; cf. Federal Ministry of the Interior and Home Affairs (BMI) 2022), are based on a holistic approach and take a society-wide perspective. At the same time, all possible dangers should be taken into account. In this regard, the involvement of civil society representatives (NGOs, associations, etc.) can lead to a strengthening of social cohesion, as it is also a characteristic of a resilient society.

A positive side effect of the Corona crisis from a resilience and environmental perspective was the "build back better" approach typical of resilience, which goes beyond restoring the pre-crisis constellation and also sees the crisis as an opportunity to overcome previous obstacles to development. The approach requires trust in the acting people and institutions but also trust in one's own abilities to be capable of dealing with the new constellation successfully (Walz et al. 2022, p. 17). This applies to dealing with climate change, both socially and individually, as well as to shaping the upheavals in the course of the digital transformation. In all cases, people must be empowered to respond to the crises, to find collective answers to the challenges and then also to implement them in an individually appropriate way.

In regard to social resilience in the face of climate change, its scope for action is also expressed in approaches such as the "Just Transition" (International Labour Organization [ILO] 2015) for change in regions characterised by traditional and fossil industries or also in the current discussion on energy poverty (Wiggenbröker 2022) due to price increases for fossil raw materials caused by the Ukraine war. In this context, the welfare state must claim to implement compensation mechanisms, e.g. climate money for low and medium income households (Felschen 2022), in order not to endanger social peace as a prerequisite for a functioning and changeable and thus resilient society.

The current crises – including natural disasters, pandemics and refugee flows – are the effects of human intervention in nature that are now perceptible to the wider society. The need for action is becoming increasingly clear, leading people in part to be willing to make cuts themselves in order to counteract climate change (Gellrich et al. 2021, p. 17). At the same time, however, the succession of crises can minimise society's willingness for sacrifice (Barchet et al. 2021, p. 13), which in turn leads to the accumulation of such crises in the long term. In Germany, the majority is aware that current disasters

such as the flood in 2021 in parts of Germany with more than 180 deaths are only symptoms of climate change (RedaktionsNetzwerk Deutschland [RND] 2021). Despite the severity of the impacts it is difficult to keep combating climate change in mind – and so current crises often take precedence over the climate crisis at the individual level (Gellrich et al. 2021, p. 10).

Conclusion for environmental policy and research:
The concept of resilience can be found in a variety of environmental and sustainability policy strategies and discourses and offers numerous points of contact for environmental and sustainability policy fields of action. The concept of resilience is relevant for UBA/BMUV– as the Emerging Issues show – because resilience has connections and interactions with the measures and goals of environmental policy in many fields of action of environmental policy.

The German Sustainability Strategy includes strengthening societal resilience in its vision for a sustainable Germany (Die Bundesregierung 2021, p. 28). In business, too, the term is now frequently used in connection with sustainability. Companies or investors describe resilience as an important factor for strong business models or investments.

However, the use of the term by various people and organisations does not necessarily result in a consistent understanding and coherently derived consequences for action or goals (Rudloff 2022, p. 31f.). The question of the common target criteria of resilience and environmental policy or sustainability policy is central, however, because if resilience is regarded as a guiding concept, it is necessary to have a comprehensive, systematic, normative definition of the concept as well as corresponding operationalisations.

This includes, among other, a clear differentiation from similar approaches and concepts such as risk management in order for the resilience concept to particularly bring structural and systemic thinking as well as interdependencies (Rudloff 2022, p. 31). It also includes an open discussion of conflicting goals that appear to be resolved or overlaid by the concept of resilience. For example, in regard to more regional supply chains, which appear sensible from a resilience perspective, it is by no means certain that these are also the better option from an environmental perspective.

2.6 Mobile work, mobile workers and mobile organisations

Trend: Digital technologies now make mobile, remote working possible for many employees.Thus, mobility behaviour, work organisation, settlement structures and also the boundaries between work and private life are changing. For the companies and organisations affected, there is a need for numerous adjustments, for example with regard to the technical infrastructure or the office organisations and capacities, but working relationships and other social aspects of everyday working life will also change.

Emerging Issues:

- Relocation through mobile working
- Dynamic developments of virtual cooperation
- Virtualisation of companies

In a nutshell:

- Digital technologies allow office and knowledge work to be increasingly mobile and location-independent. The Covid-19 pandemic suddenly forced the widespread introduction of existing, individual developments and subjected them to a reality check. Mobile working contains a number of opportunities as well as challenges for employees and employers. In particular, the potential removal of time and place limits on work requires, among other, an adapted understanding of leadership, new agreements for teamwork, the adaptation of organisational processes and structures as well as a range of individual competences preventing conflicts, imbalances or psychological exhaustion.

- Because there is no longer the need to constantly be physically present in metropolitan areas and rural areas are becoming more attractive for employees as places to live. Coworking is becoming increasingly popular and workations (work & vacations) offer a welcome change from mobile work in one's home. Through the use of augmented reality and virtual reality technologies, new virtual work environments are emerging that enable location-independent collaboration in immersive, digital spaces. Hybrid working is becoming the new norm and creates organisational changes such as new spatial concepts, digital tools for collaboration and a different approach to business travel.

- Mobile working has various potentials for environmental protection, one important aspect of which is occupational mobility. Working from home reduces emissions from motorised commuting. In addition, collaboration via virtual channels can replace business trips and thus save on transport-related emissions. When employees relocate, it is essential from an environmental perspective that this does not lead to an increase in motorised private transport or even air travel,

and that environmentally friendly and space-saving construction is carried out and open spaces are protected from urban sprawl.

Background:
With the advancing digital possibilities, office and knowledge work can increasingly be done independent of location and flexible in terms of time. As knowledge work becomes less dependent on physical media such as paper, the office as a place of "industrial knowledge production" is becoming superfluous (Florian 2021). Mobile working means that work can be done from different places that are outside the first place of work (Vereinte Dienstleistungsgewerkschaft [ver.di] 2022). This can be one's own home – home office/home work – or another company location, but also, for example, a café, a coworking space near one's home, a specially converted hut in the garden (garden office) (Cogley 2020), a rented finca in Spain (workation) or a van converted into an office (vanoffice).

Due to the Covid-19 pandemic and the associated curfews and school closures, many employees found themselves working from home either voluntarily or by necessity. Before the pandemic, only 4% of employees worked mainly or exclusively from home; in January 2021, the number rose to 24% (Statista GmbH 2021, p. 2). According to the ifo Institute, 56% of jobs in Germany can potentially be done from home. Whether a workplace is suitable for working from home differs from region to region and depends on the industry; jobs in the service industry and those in urban locations are better suited for remote working. Furthermore, it can be seen that home office workers are significantly more often employed in formally higher-level areas of responsibility than respondents who work on-site, which correlates with income and education level (Alipour et al. 2021).

Due to demographic change, the German labour force will decline by around 10% by 2035 (Michelsen 2020). In order to continue to realise the overall economic growth potential, it is therefore important to enable more people to enter the labour force who have not been active in the labour market so far – for example, because of family care work. Against this backdrop, more flexible working time models that enable a better reconciliation of family and work will become more important in the future and home office is likely to be used more intensively (Michelsen 2020). Being able to work remotely is becoming an increasingly important factor in assessing employer attractiveness and competing for qualified personnel.

Challenges for employees and employers
Surveys show that every second person wants to continue working remotely after the end of the pandemic. The advantages for employees are obvious: independent work management, less social control, better compatibility of family and work, no travel and travel costs. However, there are alsodisadvantages: The loss of social contacts and even social isolation; no water-cooler conversations with colleagues and missing informal agreements; lack of space; lack of technical equipment; dissolution of the boundaries between work and private life; psychological stress and possible emotional exhaustion; multiple stressors, which predominantly affect women (Hans-Böckler-Stiftung 2020; Jung 2020; Vereinte Dienstleistungsgewerkschaft [ver.di] 2022); constant accessibility up to "Zoom fatigue" (Sklar 2020); lack of ergonomic equipment with potential damage to health (Sawatzki 2021) and the shifting of additional costs for e.g. internet, heating and electricity onto employees. This is accompanied by increasing demands on living space, such as the desire for a larger living area and a separate study, as well as a fast internet connection.

For employers, enabling mobile working is also associated with opportunities and risks. One positive aspect is that the need for office space decreases, which makes it possible to reduce operating costs and, if necessary, to consider a change of use, for example by converting office space into living space. In turn, the provision of infrastructure such as computers, software, telephones, office furniture, etc., which may be required twice, as well as the guarantee of data protection (Franzka 2021) and IT security, can be challenging. There are also challenges in terms of labour law, especially in regard to occupational health and safety, such as conducting a risk assessment or providing an ergonomically designed workplace to ensure good health (Bergmann 2020). Finally, there are also challenges related to the quality of work: Generating a corporate culture, ensuring hybrid communication

and exchange formats, coordinating a workforce that works in a hybrid fashion as well as ensuring cohesion and supporting creativity – all these aspects depend not only on technical support systems such as suitable video conferencing systems or possibly VR applications in the future, but also on systematically addressing the challenges mentioned in order to create suitable working conditions (Haas 2022).

Blending work and life: The dissolution of time and place requires new competences so that it does not lead to mental exhaustion

According to the Constance Home Office Study, mobile working will most likely continue significantly more often after the end of the pandemic than before it. The respondents want hybrid working, i.e. a combination of time in the office and remote working. In addition, the study shows a 12% drop in productivity and an increase in perceived psychological stress among those who return in full presence compared to those who continue to work remotely (Kunze 2021).

The flexibilisation of space and time that mobile working makes possible brings with it a new kind of freedom but also new demands on employees, teams and managers. The so-called "work-life blending" means the complete fusion of work and private life. The flip side of the singularisation and subjectification of work, i.e. the increased importance of the individual in the world of work, is that the formerly external control — e.g. through social contexts such as offices and collective time-outs – is increasingly shifting to the responsibility of the individual. Self-discipline and time management thus become core competencies. The modern idea of the strict separation of work/leisure, public/private and work/home is disintegrating. The balance between different spheres must be negotiated again and again and consciously established through active demarcation.

Emerging Issues:

The current discourse on the future of (mobile) work, which has been intensified by the Covid-19 pandemic, is multi-faceted, and the development after the end of the pandemic isunclear. Nevertheless, relocation through mobile working is likely to play a role in the future, as is the establishment of new forms of virtual collaboration or organisational changes.

1. Relocation through mobile working

If the use of digital technologies no longer requires a permanent physical presence in urban areas, new opportunities will open up for workers to choose their place of residence. Until now, the industrial structural change towards more knowledge-intensive services has mainly made cities and the well-connected surrounding areas – the "commuter belts" – attractive (Wiedemann 2020). Due to mobile working, rural areas are increasingly coming back into focus. 44% of Germans would like to live in the countryside, 39% prefer a smaller town and 16% favour the big city as their place of residence. Currently, 31% of Germans live in large cities with more than 100,000 inhabitants (ZDF-Presseportal 2018). Since spring 2020, search queries for homes in the surrounding areas of large cities on real estate platforms have increased significantly (Michelsen 2020).

Looking at migration movements within Germany, we see a spillover effect: the capacities of the big cities are exhausted in many places and the surrounding areas of the ten largest cities are continuously attracting people. But it is not only in the classic "commuter belts" of the big cities that migratory movements are occurring. In the meantime, there is also talk of "urban villages" or "affluent spots". These are places that, like "commuter belts", attract new residents from the big cities. Committed municipalities recognise the opportunity for the revitalisation of structurally weak regions and are working specifically to make their location attractive for an urban, mobile working milieu. In this context, (1) a very well-functioning digital infrastructure, (2)

a well-developed transport infrastructure and (3) a basic framework of knowledge infrastructure — i.e. day-care centres and schools in the locality, universities within easy reach — are decisive for the attractiveness of a municipality for mobile workers (Wiedemann 2020).

Furthermore, co-working is now not only a concept in the big cities, but is also practised with a wide and varied range of offers in rural areas at home and abroad: either new co-working spaces that establish themselves along popular commuter routes, in small-town shop premises, in popular holiday regions or on the farm on the edge of the village (Schmied 2020).

Almost half of Germans who work from home would like to work from another location from time to time (Hirth 2020). The phenomenon of doing one's work in a holiday location is also called "workation" – a combination of "work" and "vacation". Unlike "digital nomads", who are constantly on the move, workation is about a temporary change. As mobile working increasingly plays a role in employer branding, employers are also financing (shared) workations, e.g. to promote a sense of teamwork in digital times or for employers to experience the company culture (Gode 2021).

Mobile working is also interesting from an environmental perspective. Particular attention is paid to the question of how the journey to work is normally made and how many emissions are saved if the work is done from home instead. If more people work in a home office, the emissions caused by commuting by car are also reduced. A conservative estimate assumes emission savings of 1.6 million tonnes of CO_2 e (CO_2 equivalents) per year, provided that 25% of employees work at home one day a week, thus saving about 10.9 billion passenger kilometres. A more generous scenario even calculates savings of 5.4 million tonnes of CO_2 e. if 40% of employees engage in remote working two days a week, thus eliminating 35.9 billion passenger kilometres (Büttner and Breitkreuz 2020). However, the emissions that occur in the office must also be taken into account and the additional domestic emissions must be offset. In principle, however, the avoided emissions from commuting and office operations outweigh the additional domestic emissions (Acerini et al. 2021). However, this strongly depends on the season. Especially in winter, it is more efficient

to work in the office in Germany, when heat consumption is highest and this is typically served by heating oil and gas (Acerini et al. 2021).

With an increasing relocation of employees to rural regions, it is important to consider the extent to which this potentially influences the environmental impact if public transport is not well developed in these regions. As a result, the car is increasingly used for both leisure and work trips. Even assuming that the hybrid working model prevails and work is not exclusively mobile, part of the working time still has to be performed in the office in the city centre, which can lead to increased commuting. Central to this is the mode of transport used to get to work and whether alternatives to the car exist so that transport-related emissions can be reduced. Rural coworking spaces or satellite offices offer the potential to reduce commuting, as employees at least have a shorter way to work and do not have to drive to the office in the city (Bähr et al. 2020). Another important aspect in correlation with the relocation of employees to surrounding areas is land-use, because the increase in settlement and transport areas is often at the expense of agricultural land, which has important soil and habitat functions (Bundesministerium für Ernährung und Landwirtschaft [BMEL] 2020).

2. Dynamic developments of virtual cooperation

Already today, there are offers that enable hybrid working. In addition to tools for (group) communication such as video conferences, there are a number of tools for digital collaboration, e.g. cloud storage for documents and data, cloud software, wiki systems or online whiteboards. These can

facilitate exchange between hybrid working people (Grzegorczyk et al. 2021).

In the future, the use of virtual reality (VR) and augmented reality (AR) technologies could become particularly important. Originally driven by the computer games industry, this development has now also found its way into professional life (Jetzke et al. 2020, p. 24 ff.). For example, there is the Horizon Workroom from Oculus, an immersive environment in which collaborative work is made possible by means of various tools, such as mixed reality (MR) tables, tracking of keyboards and hands, screen transmission and virtual avatars, among others (Oculus Blog 2021). In the process, MR environments could become even more ubiquitous and not just limited to professional life. Facebook's rebranding under the new name "Meta" is accompanied by the announcement of its intention to develop a so-called metaverse where users can visit immersive environments using VR and AR technologies. The Meta group even sees MR environments as the next generation of the internet (Blug 2021; Heckel 2021). There are still obstacles in the diffusion of VR technologies, as VR glasses in particular do not yet recommend themselves for permanent use. In regard to wearing comfort and other technical aspects, there are still development steps to be taken before widespread usage can be expected.

If collaboration between employees increasingly takes place virtually instead of in person in the office, the data volume of applications for video conferencing, but also of the VR and AR technologies mentioned, will increase. In Germany in 2020, during the Covid-19 pandemic, the landline-based internet data volume for private and professional purposes rose to 76 billion gigabytes, 16 billion gigabytes higher than in 2019 (Bundesnetzagentur 2020). Due to new technologies and cooling methods, data centres, and thus also the energy consumption per gigabyte transmitted, are becoming more efficient, but at the same time the need and demand for computing capacity is increasing (Masanet et al. 2020). The amount of data generated, captured and replicated annually could grow from 64.2 zettabytes[18] in 2020 to 181 zettabytes by 2025 (Tenzer 2022) — almost tripling in just five years.

Ideas like the metaverse are a good example of how immersive and comprehensive, and thus also data-intensive, virtual living and working together can be. However, how long the increases in efficiency will be able to compensate for the growth in data volume in terms of energy consumption is still open for debate (Freitag et al. 2021). The CO_2 intensity depends strongly on energy procurement, especially on the share of renewable energy sources (Friedrich et al. 2021). The largest telecommunications companies still have deficits in this area: on the one hand, with regard to their share of renewable energies, and on the other hand, with regard to their reduction targets (Greenpeace USA 2017).

Nevertheless, virtual and hybrid collaboration offer great potential to avoid business trips and thus also the emissions that arise in the process. Surveyed employees expect that video conferences will be able to replace both internal coordination (66%) and external meetings (56.9%) in the future (Wuppertal Institute for Climate, Environment and Energy gGmbH and Ernst & Young GmbH Wirtschaftsprüfungsgesellschaft [EY] 2020).

3. Virtualisation of companies

There are now "virtual-first companies" (or also "remote-first") that turn the logic around: Most of the work is done remotely and people only go to the office when a face-to-face meeting adds value, e.g. for team building, staff meetings, brainstorming, strategic decisions (Florian 2021). To make hybrid collaboration successful, four factors are crucial (Grzegorczyk et al. 2021):

The *office as a physical space needs to be reimagined*. When the majority of work is done remotely, offices take on a new role: on the one hand, they become places for collaboration, creativity and social encounters and are equipped, for example, with flexible seating, whiteboards and conference systems (Florian 2021). Individual workplaces and offices are being replaced by desk sharing, and companies are opening satellite offices in suburbs (Cox-Nowak 2021). On the other hand, it currently still seems unclear whether the demand for office space, especially in city centres, will decrease in the long term and bring

18 1021 Bytes

new possibilities for the conversion and design of city centres.

Choosing the right digital tools and collective timing are crucial for virtual collaboration. It is important not to simply translate communication 1:1 into the digital sphere, otherwise whole days are quickly filled with online conferences (Florian 2021). The benefits of digital collaboration can be realised above all when companies deliberately set aside times for "deep work", i.e. times for undisturbed, concentrated work (Newport 2016).

The corporate culture is based on trust, is inclusive and can be experienced digitally. In a digital work environment, implicit norms and rules of the corporate culture are more difficult to recognise, especially for new employees. Therefore, it is important that leadership at a distance is based on trust, commitment and a constructive way of dealing with mistakes and giving feedback. Processes should be deliberately designed so that mobile workers are not unintentionally disadvantaged in career steps, e.g. promotions. Relationship management and the creation of common rituals and forms of encounters are increasingly becoming a leadership task (Florian 2021). Employers are increasingly offering virtual activities such as online cooking courses or yoga sessions (Bergmann 2020).

Company-wide guidelines regulate how cooperation works. These include, for instance, explicit agreements on expectations regarding accessibility and response time. Because online meetings are often more tightly organised and more efficiently held, they are usually also more strenuous than in-person meetings. The possibilities for interpreting voice modulation, body language or behaviour are severely limited in digital means of communication (Wintermann 2021). The ambiguity of punctuation, emojis and GIFs also leads more easily to misunderstandings in digital communication. Therefore, team agreements are important to ensure that there is a common understanding and that only those whom it concerns are systematically included in the communication (ada Editorial 2019).

The number of business trips had been increasing for years before the Covid-19 pandemic. Since the beginning of the pandemic, it has been closely examined whether a trip is actually necessary or

whether it cannot be replaced by a video conference (Hampel 2020). According to the ifo Institute, 57% of German companies consider it likely that they will permanently reduce their business travel (ifo Institute 2020). Business trips are becoming more time-consuming and expensive and thus increasingly a question of hierarchy: In the future, it will be mainly higher levels and specialists who will travel (Hampel 2020).

The described changes within organisations can bring positive environmental impacts. Apart from the potential savings from a reduction in commuting already mentioned, reducing business travel offers the potential to reduce emissions in the transport sector. Both business travel and commuting each accounted for around 20% of total passenger transport in 2019 (Umweltbundesamt [UBA] 2021). Particularly relevant from an environmental perspective is air travel, the most energy-intensive form of transport. In 2019, one third of all flights were taken by business travellers (Deutsches Zentrum für Luft- und Raumfahrt e. V. [DLR] 2020). Of all domestic flights, as many as 65% of passengers were business-related (Bundesverband der Deutschen Luftverkehrswirtschaft [BDL] 2018). If business trips are made less frequently due to a changed organisational culture, CO_2 emissions and other climate-relevant emissions can be reduced.

Conclusion for environmental policy and research:
It is not yet possible to assess with certainty how the future of mobile work will be and to what extent the short-term behavioural changes during the Covid-19 pandemic, for example the increase in working from home and the decrease in business trips or

commuting, will continue. From an environmental policy and research perspective, the dynamics of the young trend of mobile working need to be closely monitored and evaluated. Do technological developments, e.g. in the field of virtual reality, possibly cause drastic environmental effects or will they be used on such a large scale that there will be an even higher level of energy consumption? Indirect effects also need to be assessed: will emissions be reduced in the long term through mobile working by decreasing commuting and business trips? Or will they only be shifted elsewhere because cars are bought and longer distances between the village and the city are covered instead of commuting by local public transport?

However, environmental policy can also help shape positive developments for mobile working in this area and has various starting points. One option would be to make home office expenses more tax deductible or to create incentives for co-working spaces in suburban and rural areas through subsidy programmes. Likewise, the tax incentives for commuting should be reflected on and, if necessary, reduced. The promotion of concrete efficiency and climate protection measures for data centres and an environmentally friendly design of AR, MR and VR technologies can be another supportive measure to minimise the environmental impact of virtual work. In addition, regional, settlement and tourism management should be strengthened and environmental concerns should always be taken into account, for example when employees relocate to other regions.

2.7 Growing through crises: The EU's changing scope for action

Trend: The multiple crisis management in light of the Russian war of aggression in Ukraine, the ongoing Covid-19 pandemic, Brexit or the rise of populist and nationalist movements pose a challenge to the European Union's ability to act and the progress of the EU integration process. At the same time, room for manoeuvre is opening up for dealing with global challenges such as the climate crisis.

Emerging Issues:

- Integrated approaches to intertwined crises open up synergies.
- Supporting EU policies through institutionalised foresight
- Citizens as part of more participatory politics

In a nutshell:

- The multiple crises that have emerged since the beginning of the global financial crisis in 2008 pose a challenge to the European Union's ability to act and the progress of the EU integration process. In the course of this polycrisis, on the one hand, patterns of progressive erosion are emerging, for example due to individual states acting on their own. On the other hand, opportunities for more integration and for a common crisis management policy are emerging, especially since nationally limited initiatives cannot address the complexity of the crisis situations.

- With integrated approaches such as the Green Deal and the NextGenerationEU economic stimulus programme, the EU is trying to increase the scope for action to overcome current crises and strengthen its future ability to act. The institutionalisation of strategic foresight and the strengthening of the European population's opportunities for participation, for example through citizens' forums and conferences, are intended to support these goals.

- The environmental impacts of these developments are currently difficult to assess. Serious crises could lead to a significant weakening of the EU's sustainable climate and energy governance by absorbing political attention and reducing financial margins. In response, the Green Deal represents an integrated and strategic governance approach to achieve the goal of climate neutrality by 2050 and biodiversity recovery in Europe by 2030. In addition, the use of participatory instruments is intended to increase acceptance for the implementation of far-reaching transformation policies and improve the quality of political decisions.

Background:
At present, the European Union (EU) seems marked by ongoing crises: The Euro crisis/financial crisis and the resulting economic crises since 2008/2009, the increase in migration and refugee movements to Europe in 2015, the Ukraine crisis, which began in 2014 with the annexation of Crimea by Russia and led to the Russian war of aggression against Ukraine in February 2022, the strengthening of populist, protectionist and nationalist currents, the rule of law crisis in Eastern Europe, Brexit in 2019 and, last but not least, the Covid-19 pandemic since the beginning of 2020.

Due to the multitude of crises, there has already been talk of a "polycrisis of the EU" (von Ondarza and Lübkemeier 2017; Grimmel 2020). It is accompanied by a rise in social inequality, scepticism about science, post-factual communication and political leadership, as well as new challenges for the legitimacy of political action at the European level (Wittpahl 2020; Homeyer et al. 2021). These developments do not stand side by side, but rather form a complex and dynamic web of interactions that challenge the EU's ability to act. The powers given to it by the European treaties, its organisational form and its budget mean that the EU is always struggling for room to manoeuvre.

Criticism of the European Union
The EU's ability to act has been criticised not only since the Covid-19 pandemic. Major points of criticism include:

- The decision-making capacity, which is largely based on the majority principle, but in the Common Foreign and Security Policy (CFSP) must be based on the unanimity principle. This means that individual member states can block decisions until they have obtained concessions in other areas (Lübkemeier 2021, p. 3). For this reason, the implementation of the majority principle is also demanded for the CFSP, e.g. currently by the Conference on the Future of Europe. However, majority decisions have an inherent tension between effectiveness and legitimacy. Above all, EU members whose rule of law is increasingly questionable, e.g. Poland or Hungary, can reduce the legitimacy of majority decisions, for example by contributing to the majority decision-making process but opposing the decisions. One example is the redistribution of refugees, which is not implemented by Poland and Hungary (Lübkemeier 2021, p. 3). However, the envisaged implementation of mechanisms (infringement proceedings, withholding of EU funds, etc.) can then be to the detriment of effectiveness, for example because time delays occur.

- The coordination effort and the creation of a balance of interests between the EU and the member states can be a hindrance to the ability to act due to the multi-level system (Landeszentrale für politische Bildung [lpb] 2022). The shift of competences from the national to the EU level could strengthen the capacity to act, especially in dealing with crises where fast and effective action is required (ibid. 2022). However, there are very different views between the member states on how responsibilities are distributed, national interests compete with higher-ranking goals, which again became clear in the example of the distribution of refugees among the EU states or the at times noticeable disagreement regarding the fight against the Covid-19 pandemic (Riegert 2021).

- Ultimately, this is linked to concerns about the declining trust of citizens in European institutions. Different surveys show a rather ambivalent picture: there are surveys that point to a decline in trust, especially in connection with the Covid-19 crisis (Hans Böckler Foundation 2020), as well as surveys that suggest a constant level of trust (Heinrich Böll Foundation 2021), or even those that paint a picture of increasing trust (European Commission 2021h). However, different attitudes towards the EU become apparent, especially when comparing countries, for example when it comes to the question of whether the citizens of the individual countries feel European at all (Landeszentrale für politische Bildung [lpb] 2022).

In view of the criticism, it seems obvious to doubt the EU's ability to solve the ongoing crises. The erosion of the European Union may also progress as a result of the above-mentioned criticisms, for example if solo efforts by individual states continue to undermine collective European processes.

Criticism as an opportunity

In dealing with the numerous crises and addressing the criticism, however, there is also an opportunity to implement an effective crisis policy and for more integration, in that individual states or groups of states recognise that crisis situations cannot be managed on their own (Laffan 2019). For example, it was possible to organise a joint vaccine procurement during the Covid-19 pandemic (European Commission 2020c) or to create a Europe-wide coordinated network of protected areas, Natura 2000, as part of the common climate policy (European Commission 2022c).

The global climate- and biodiversity crises also represent a central crossroads for the EU and requires the EU's joint problem-solving competence. With the European Green Deal (EGD), the EU has already adopted a growth strategy in 2019 with the aim of implementing environmental, species and climate protection in a package that combines regulations and measures for research, development and innovation and investment in structures (European Commission 2019).

Although the EU has proven in the past that it can respond well to a wide range of crises and thus already has a high degree of problem-solving competence, it is currently difficult to predict the nature of future crises and how they will interact with ongoing crises. Therefore, dealing with crises is likely to take up more space in the context of political work in the future. That encompasses both the ability to anticipate future crises and their necessary solutions, but also includes the early development of new problem-solving skills.

Emerging Issues:

In the face of the current and emerging challenges posed by simultaneous, intertwined crises, more specifically the Covid-19 pandemic and the climate and biodiversity crisis, as well as the Russian war of aggression against Ukraine, the EU is challenged more than ever to develop integrated approaches to solutions. In addition, future crises must be anticipated early enough and living together in a community-oriented and resilient way must be proactively supported through more direct democracy and citizen participation.

1.Integrated approaches to intertwined crises open up synergies

The health crisis, which has been going on since 2020, and the societal and economic impacts of the Covid-19 pandemic are putting European politics in prolonged crisis mode. The European public has also been experiencing the climate crisis more directly due to extreme weather events and increased drought years since 2013. Meanwhile, more and more scientists are assuming that the risks of possible further pandemics and health risks due to global warming and the destruction of natural ecosystems under human influence should be focused on more strongly and precautions must be taken (Löschke and

Nabiyeva 2022). Coping with past and adapting to future climate impacts in the midst of the Covid-19 pandemic already hints at this: Dealing with multiple crises that are directly or indirectly related to the climate and biodiversity crisis could shape political events even more in the future. This possibility is shown by the EU's efforts to address and jointly solve the two developments described above in the long term.

Even before the Covid-19 pandemic, the EU Commission adopted the European Green Deal (EGD) in 2019, which aims to make the European economy and society climate-neutral by 2050; resilient to climate impacts and related economic consequences, and environmentally friendly in terms of biodiversity, soil fertility and protection of sensitive ecosystems such as the oceans via a green growth strategy. The aim is for this transformation to be socially and economically sustainable (European Commission 2019). In response to an emerging economic crisis caused by lockdowns and the collapse of value chains, the EU Commission was also able to link financial support to member states and business from the NextGenerationEU stimulus programme with the roll-out of the EGD (European Commission 2022b). The EGD was expanded to include a "green" recovery programme. The budget of the NextGenerationEU programme is to be disbursed proportionally as a grant or as a loan in order to achieve further leverage in the economy. The aim is to stimulate private-sector and national follow-up investments for socio-ecological and digital innovations and structures. A total of 1.8 trillion euros is to be raised from public and private funds (European Commission 2020b). The allocation of funds is partly linked to the environmental and climate goals of the EGD (EPA Network 2020). Countries that receive the funds commit to using more than one third of them to achieve climate goals (European Commission 2021e). The financial support is accompanied by structural reforms, e.g. through expanded CO_2 pricing and the reduction of environmentally harmful investments (EPA Network 2020).

As other economic, social and political crises may develop in direct or indirect relation to the biodiversity and climate crises, the creation of a socio-ecological growth strategy such as the EGD may provide a framework for responding to multiple simultaneous, interconnected crises and preventing future crises by linking instruments and programmes (integrated vision). How effective the EU's support and investment plans within the EGD and NextGenerationEU will be in terms of the goals set will only be assessed by research in the coming months and years.

There is a possibility that ongoing crises can lead to increased environmental or sustainability awareness in society and politics. This was already noticeable during the Covid-19 pandemic and might be also the case with regard to a possible energy crisis triggered by the Ukraine war. In this context, demands are already being voiced to save energy (Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection [BMUV] and Federal Environmental Agency [UBA] 2021; Wuppertal Institute for Climate, Environment, Energy gGmbH and eBay Kleinanzeigen 2021; SPIEGEL-Verlag Rudolf Augstein GmbH & Co. KG 2022). Increased environmental or sustainability awareness could lead to greater environmental policy integration at national and international level (German Advisory Council on the Environment [SRU] 2020). This would also increase support for the implementation of the EGD targets, namely to reduce greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels and to achieve climate neutrality by 2050. This would ensure the limitation of temperature rise as well as the preservation and reconstruction of ecosystems and their ecosystem services, access to (clean) water and the cultivation of food.

Although the Covid-19 pandemic caused delays in the implementation of individual elements of the EGD, the timetable for the most important goals, e.g. new emission reduction targets for 2030, remained unchanged and the climate policy agenda was stringently pursued (Siddi (2021). Against the background of great pressure on environmental and climate targets, this can be seen as a success. EU funds for economic recovery were also linked to the EU's climate targets and the Green Deal agenda.

Furthermore, crises can also cause conflicts of targets between the environment and, for example, security of supply. This is underlined by the current discourse on whether, due to the anticipated shortage of grain and animal feed triggered by the war in Ukraine, land areas that have been declared ecological priority areas should be released for agriculture again (Federal Government 2022). This would be a step backwards for the conservation and restoration of biodiversity. According to the German Advisory Council on the Environment (SRU), the EU's environmental policy competences have grown considerably in the last decade, but environmental policy integration still requires the implementation and enforcement of existing environmental law in member states (German Advisory Council on the Environment [SRU] 2020).

2. Supporting EU policies through institutionalised foresight

The anticipation of future crises and the timely and appropriate design of suitable coping and transformation strategies has taken on new importance, especially in the wake of the Covid-19 pandemic (Bovenschulte et al. 2021, p. 2). The ability to anticipate or foresee future developments, linked to systemic analytical capacities, can be increased by institutionalising strategic foresight (Walz et al. 2022, p. 23).

The EU recognised the importance of strategic foresight as an instrument for reducing uncertainty many years ago. A recent development is that the EU Commission has for the first time appointed a Vice-President (VP) for strategic foresight, Maroš Šefčovič. His task is to coordinate the numerous foresight activities within the EU Commission and downstream agencies and networks. Also through the VP post, the COM thus underlines the importance of strategic foresight for informed policy development against the backdrop of climate change, for strengthening resilience and on the way to more environmental friendliness, fairness and digitalisation in the EU (European Commission 2022d).

The institutionalisation of strategic foresight in organisations is something that futurologists such as Slaughter, among others, have long advocated (Slaughter 2002): In order for strategic foresight to be able to react to new developments, the continuous implementation of foresight processes is considered necessary. This requires organisational anchoring and the development of capacities such as personnel as well as interfaces to internal and external experts and networks. Slaughter further argues that this would not be sufficient if strategic foresight is not also understood as the ability to think in alternatives and motivated in the organisational culture.

The EU Commission has addressed precisely this need with the position of VP. The VP is supported by the Joint Research Center and its Knowledge4Policy platform as well as the Competence Center on Foresight. The Joint Research Center synthesises the results from contract research for the EU, EU funding projects and its own analyses and prepares them for political decision-making (European Commission 2022a). Furthermore, interfaces for inter-institutional exchange between EU institutions and authorities have been established through the ESPAS network, in which the European Parliament and the Council contribute to the foresight process. The ESPAS network is monitored by the Committee of the Regions, the European Economic and Social Committee and the European Union Institute for Security Studies (European Strategy and Policy Analysis System [ESPAS] n.d.). In addition, an interface to the member states was created. The so-called "Ministers of the Future" in each country (in Germany the Foreign Office) are to ensure the exchange between the Commission and the member states in an "EU Network for Strategic Foresight" (European Commission 2022d). In various "clusters", representatives of the member states also work with each other on concrete topics and foresight processes as well as on methodology.

With the aim of being prepared for new developments and identifying geopolitical room for manoeuvre, the Strategic Foresight Report has been prepared annually since 2020. The first report from 2020

emphasised the importance of resilience[19] (European Commission 2020a; see also chapter 2.5). In the second report of 2021, which primarily emphasised European sovereignty on the path to a climate-neutral continent, the importance of foreign policy regarding Russia was highlighted, among other things, but without specifically addressing the Russian threat to Ukraine (European Commission 2021g). This shows that strategic foresight cannot claim to predict the future but at best to open up spaces of possibility. In retrospect, however, the topics mentioned in the reports are highly relevant.

EU authorities continue to carry out their own foresight activities. For example, the Environmental Knowledge Community – an informal network of environmentally interested departments under the auspices of DG ENV – implemented the annual FORENV process for the fourth year in a row, which includes horizon scanning and assessment of weak signals. This is to be continued in order to improve the understanding of climate and environmental problems and to compile and evaluate knowledge in the EU (European Commission 2022e).

The institutionalisation of strategic foresight in the Commission enables improved exchange and the knowledge management necessary for foresight. It is an important building block for responding more sustainably to external and internal developments and increasing the resilience of the EU (European Commission 2021f).

One measure of the success of strategic foresight will be the translation of the results of foresight activities into (environmental) policy action and ultimately into concrete changes in business, science, politics and society. If foresight activities are carried out comprehensively and independently and the results are well integrated into policy, a positive environmental impact can be felt. The conditions that the EU created for the consideration of results from foresight activities in (environmental) policy-making processes are promising (Gaub 2020). The permanent establishment of a VP for Foresight is a step towards better integrating future interests into today's decision-making processes and becoming more resilient in relation to various (environmental) crises (Gaub 2020).

3. Citizens as part of more participatory politics

Anticipating and managing future crises requires not only the right competences and instruments but also the involvement of European citizens who are affected by the crises, for example because they suffer from the economic, social, health or environmental consequences. The acceptance of political measures is linked to trust in the institutions that make decisions. Although – as mentioned above – studies on citizens' trust in the EU show an ambivalent picture, recent years have increasingly led to the formation of Eurosceptic political parties (Kietz and von Ondarza 2014; Braun and Grande 2021).

In order to strengthen trust, but also to make use of the knowledge, innovative capacity and creativity of EU citizens, participatory formats, such as those already being tested at EU level, can gain in importance in the future:

- Consultations[20] for all legislative procedures are an already established instrument that is continuously being developed. Individual citizens, but above all non-governmental organisations (NGOs) and associations, can be involved in the development of laws during the drafting process. Digital tools[21] are already available for

19 See also chapter 2.6
20 https://ec.europa.eu/info/about-european-commission/service-standards-and-principles/transparency/consultations_de
21 https://ec.europa.eu/info/law/better-regulation/have-your-say_de

this purpose. At the end of 2021, guidelines (European Commission 2021a) and a toolbox (European Commission 2021b) were published for better support of the European Commission in conducting consultations.

- Another instrument to increase the participation of EU citizens is the Conference on the Future of Europe.[22] Established in May 2021, the EU Commission addresses all European citizens directly. Their participation is possible through various online and offline formats, including a digital platform in all EU languages. Topics such as climate and the environment, democracy in Europe, the economy, values and rights, the rule of law and security, digital change, migration, education, sport, culture, youth and the role of the EU in the world (European Parliament 2022) are being discussed discussed. The results of the discussions are evaluated and summarised by analysts and with help of digital technology such as text mining. They are then published (Conference on the future of Europe 2021) and discussed in a plenary session. The process ended in May 2022. The EU dealt with the proposals in a binding manner within the Commission and in the Parliament and initiated various changes based on the proposals arising from the conference. These include abolishing the right to veto in many areas, as well as greater integration in the areas of health, energy, defence and social and economic policy. Further measures are to be included in the Commission's work programme for 2023 (European Commission 2022f).

- A third instrument is the so-called citizens' forums, in which randomly drawn (representative) citizens of the EU discussed individual topics within the framework of the Conference on the Future of Europe in 2022 (Bürgerrat.de 2021). In addition to face-to-face meetings, the discussions were held online. Citizens' forums are also by no means a new instrument of participation (Wissenschaftliche Dienste 2009), but they can be used even more frequently at EU level in the future, as is already happening in Germany and other member states.

- Citizens are also increasingly involved at the level of implementing funding instruments. The process of the new so-called five EU missions sees participation as an essential pillar in order to involve society in achieving ambitious goals for research, development and innovation and to jointly develop solutions in co-creation with business, public administration and research. For example, the missions "100 climate-neutral, smart cities by 2030" and "adaptation to climate change" envisage interdisciplinary work on new solutions, e.g. for climate-neutral mobility and interactive urban planning methods in 100 cities – and on the other hand, for example, on effective regional participation methods for the 150 regions. It is also interesting to note that EU funding of one billion Euros per mission is being used to achieve the broadest possible leverage effect with respect to this large number of cities and regions. Participation is seen as a key to launching sustainable social innovations and creating identification with EU goals at the local, regional level. The practical solutions as well as the methodological knowledge on participation and its reflection through an accompanying, continuous evaluation of the missions by the respective mission platforms, i.e. the coordination platform, will later be made available to other cities and regions. In this way, they should also be enabled to successfully use participation, among other things, to also achieve the EU goal of climate neutrality 2050 and climate adaptation. Officially, the pilot cities and regions will start in 2022 (European Commission 2021c; European Commission 2021d), so no impact can be estimated yet.

- Finally, the further development of the European electoral system is also an instrument to increase participation. Surveys indicate that almost 60% of Europeans surveyed are dissatisfied with the democratic reality (Foa et al. 2020). In another representative survey, 54.8% of young adults from Germany stated that they did not regard themselves sufficiently represented by the parties standing for election (Jugendrat der Generationen Stiftung 2021). The call for electoral reform, similar to the three instruments mentioned above,

22 https://futureu.europa.eu/?locale=de

is by no means new (Müller 2020), but may receive new impetus against the backdrop of addressing ongoing crises.

Research is relatively unanimous that participatory instruments foster innovation and acceptance among citizens and thus promote the implementation of a transformation (here: the transformation towards sustainability) (Bohn and Fuchs 2019; Olliges 2019). This is relevant because in democratic societies far-reaching policy measures, such as climate protection, depend on broad legitimacy in the political sphere (Renn 2020). A prerequisite for this is a form of participation where the results actually find their way into political decision-making processes or are transparently fed back to the citizens. Sherry Arnstein established the ladder of participation as early as 1969, which is still used today. According to this, participation formats can vary from "token participation" and "decoration" (at the lower end of the ladder) to genuine participation or even self-determination (at the upper end of the ladder) (Arnstein 1969; Radtke and Canzler 2019). Formats at the lower end of the ladder run the risk of being degraded to a ritual or "fig leaf participation" without real influence on the political decision-making process, which can lead to frustration and resignation among citizens (Claussen 2013). Involving citizens in European policy processes can therefore help to counteract this resignation and create more knowledge about the procedures and thus potentially also a stronger sense of belonging to the European Union. However, citizen participation is not only about increasing the acceptance of policy measures. Participation research assumes that citizens' knowledge is a valuable resource and that the inclusion of their (local) knowledge increases the quality of political decisions (Alcántara 2016).

Conclusion for environmental policy and research:
The multiple and interwoven crises affect the EU's scope for action in its environmental policy. On the one hand, the crises could have a positive impact on environmental policy integration by creating greater urgency and acceptance for action. On the other hand, attention and resources could be diverted to other, seemingly more urgent issues. The use of synergies of political measures – e.g. preservation of ecosystems for nature conservation on the one hand and pandemic control etc. on the other – in different fields of action makes sense, but can only work if corresponding measures are implemented

consistently. Although the EGD as a central strategy guides action, it requires implementation and support by the member states.

Institutionalised foresight can serve to identify crises at an early stage and to prepare for them politically and socially and to explore different options for action. This is particularly relevant because crises often originate and occur beyond national borders. Therefore, it is also important for German environmental policy to cooperate with the European level and to jointly develop strategies for (environmentally relevant) future issues. Results of the foresight analyses should be communicated to the public in a practical and action-oriented manner.

For an effective and sustainable environmental policy, a scientific foundation of political measures, democratic legitimisation through increased participation of citizens and solidarity between the member states are of great importance. These can become the motor for the implementation and diffusion of social and socio-technical innovations to avoid or, if necessary, adapt to climate impacts, which require individual and collective action. It is precisely the linking of national and European levels that can make it possible to learn from each other and work on environmental issues together, which can contribute to increased crisis resilience in the long term.

2.8 World (dis)order

Trend: The old, Western-dominated world order is experiencing a phase of rapid upheaval. The confidently acting People's Republic of China is increasingly asserting its national interests and is in a battle for global technological leadership with the domestically polarised USA. Russia is relying on military aggression and is initiating a war in Europe with its attack on Ukraine. The European Union is searching for its new role in the world. .

Emerging Issues:

- The beginning of the post-multilateral era?
- Polarisation of US domestic politics
- Europe and the Sino-American technology conflict

In a nutshell:

- The stability of the international order is under pressure from volatile foreign policy developments. Russia's war of aggression against Ukraine may mark a turning point in the ongoing crisis of multilateralism. The political vacuum in the US left by the Trump administration is being filled not only by authoritarian regimes such as the People's Republic of China and Russia, but also by sub-state actors such as the non-partisan "U.S. Climate Alliance" consisting of 13 states, as well as non-state actors such as private foundations or companies.

- The uncertain direction of US foreign policy is flanked by an increasing polarisation of US domestic politics. The currently questioned balance of power between the large industrial nations USA, Russia and China could shift in favour of other states. In the midst of these developments, Europe, or rather the European Union, has to determine its role in an emerging new world order.

- The emerging geopolitical changes will have an impact on international and national climate and environmental policy. The competition for technological leadership between China and the USA may result in economic and social changes and require adapted economic, social and also environmental policies as well as a realignment of international relations.

Background:

Western democracies depend on a stable, efficient international order. Germany's economy, in particular, depends heavily on a liberal, rule-based global economic order due to its high export orientation. Urgent societal challenges such as climate protection or protection against pandemics, which have a global dimension, can only be solved through concerted, international action.

At present, the stability of the old, western-dominated world order is being threatened: the most recent example of this is the war of aggression being waged by Russia against Ukraine. This event and the reactions to it can be described at the present time (as of 03.03.2022) as a "turning point in time" (Federal

Government 2022), or also as a "new age" (Federal Foreign Office 2022). Despite rapid international reactions ranging from economic sanctions against Russia to the exclusion of Russian athletes from international competitions, blocked airspace and military support in the form of weapons deliveries and the redeployment of NATO troops, the further development of the war is unclear. It is conceivable, however, that this will mean a major rupture in the multilateral world order, for example if new partnerships are formed to secure gas supplies, as with Qatar, or if new geopolitical partnerships are formed or existing partnerships are strengthened, for example between China and Russia or Iran and Russia. Already under former US President Donald Trump, a departure of the former superpower USA from the project of multilateralism, i.e. the policy coordination of several states, became apparent, for example in the withdrawal of the USA from the Paris Climate Agreement, the World Health Organisation (WHO), the Washington Treaty on Intermediate-Range Nuclear Forces (INF), the Iran nuclear agreement and the Trans-Pacific Free Trade Agreement (TPP) (Schaller 2019). These steps had long been unimaginable for many Europeans.

Current developments influence US foreign policy goals

Trump's successor, President Biden, is striving to fulfil the high expectations regarding a return of the old superpower, the US, to the world stage; but in view of a profound political division in the country, which not only affects the electorate but also manifests itself between the political wings of the established parties, it is very uncertain to what extent a coherent US foreign policy can be expected in the longer term. Current developments, such as the Russian war of aggression in Ukraine and the tensions between China and Taiwan, can dramatically change the fundamental and strategic US foreign policy objectives in the short term. A clear picture of the future role of the US in the international community and a positioning in the competition with China is not yet discernible.

In the course of the Russian war of aggression in Ukraine, the US enforced sanctions against Russia and provided generous financial and military support to Ukraine. At least at this point in time, it can be stated that Russia nevertheless continues to strive to enforce its own national interests by military means, regardless of the applicable rules of international law and unimpressed by internationally coordinated sanctions. This underpins its claim to be a hegemonic force in the world. In this respect, the question of the future relationship between the US and Russia cannot yet be answered. Since both the US and Russia are nuclear powers, a direct military confrontation between the two states could lead to a spiral of escalation with extreme consequences for all of humanity. Although Russia has repeatedly made threats regarding the possible deployment of nuclear weapons, there are nevertheless efforts to continue international arms control and nuclear disarmament in order to avoid this escalation (tagesschau.de 2022a; tagesschau.de 2022b).

Whether China will follow Russia's example and rely even more on military means to enforce its own interests in the ongoing conflicts with neighbouring countries such as India or Taiwan, or trying to influence Western democracies by creating economic dependencies, is not yet foreseeable at present (Kaim and Stanzel 2022). It is also currently unclear whether China will take a clear position against the background of existing military cooperation with Russia (ZEIT ONLINE GmbH 2022). In this respect, it remains questionable to what extent the US will restructure its strategic relations with China or its allies in the Pacific region. However, it is within the realm of possibility that a military action by China against Taiwan could lead to an armed conflict between the US and China (Wetzel 2022).

Emerging Issues:

In the current discourse on the race for a good position in the new world order, multiple, interrelated lines of development are emerging. Above all, the one caused by recent armed conflicts in Europe could lead to a post-multilateral era. What it might look like is currently completely open and depends on the further course of geopolitical changes. Moreover, the increasing polarisation of US domestic politics could weaken the US in the future and shift the balance of power in favour of other states. Meanwhile, the European Union is seeking its role politically as well as economically in an ongoing conflict for technological leadership between China and the US.

1. The beginning of the post-multilateral era?

The emerging crisis in multilateral relations has reached a new level, if not a turning point, with the start of Russia's war of aggression against Ukraine on 24 February 2022. At present, it is not possible to make a reliable assessment of the outcome of this war of aggression, let alone what the world order will look like after a possible end to the conflict. However, it is clear that existing multilateral institutions and partnerships will have to rethink their meaning, as the rule-based multilateral order is continuously challenged at different levels, in particular by: i) regular blockades in the UN Security Council due to the veto power of the five permanent members; ii) clear violations of international law by Russia, such as the war of aggression on Ukraine; iii) a selective application or reinterpretation of international law, such as China's claim to territories in the South China Sea or the disregard of relevant rulings of the European Court of Justice by some EU member states; and (iv) a decreasing willingness of a number of states to submit to new commitments and obligations. This includes, for example, the questioning and underfunding of key institutions of the multilateral order, including by the Trump administration. The pointed absence of the two heads of state Vladimir Putin and Xi Jinping at the 26th UN World Climate Conference COP26 also falls into this category (Auswärtiges Amt 2021b).

Moreover, western-style multilateralism, including the underlying liberal norms, has been openly questioned for some years. Not only has China been expanding its influence in international organisations for years, especially in the UN system (Woods 2021) or in standardisation organisations, Beijing is also pursuing "competitive multilateralism" by setting up competing organisations or informal alliances that undermine western-dominated institutions. The most significant example of this is the Asian Development and Infrastructure Bank (AIIB). The "New Silk Road" (BRI) co-financed by the AIIB epitomises China's intention to build a rival political and economic order worldwide (Ikenberry and Lim 2017).

In order to compensate for the above-mentioned weaknesses of the established organisations, transnational partnerships with non-state and sub-state actors have increasingly been established alongside informal, state cooperation and coordination mechanisms, such as the G7[23]/G20[24] or the "Alliance for Multilateralism" (Federal Foreign Office 2020). In international climate policy, this process was officially launched at COP 20 in Lima in 2014, when the "Lima-Paris Action Agenda" (LPAA) (United Nations [UN] 2015) and the "Non-State Actor Zone for Climate Action" (NACCA)[25] were launched. The "Transatlantic Climate Bridge" of the Federal Foreign Office and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, initiated in 2008, aims at a close exchange with non-state and sub-state actors in Germany and the US (Auswärtiges Amt 2021a). These transnational partnerships become more important as the role of the U.S. as a global power becomes more volatile and the emergence of authoritarian regimes such as the People's Republic of China threatens to get more dominant.

In the past, the example of climate diplomacy has already shown that Europe has found ways to deal with the crisis of multilateralism, especially with the temporary absence of the US. In preparation for the 2019 Climate Action Summit, which did not include the US under Trump, Europeans worked alternatively with other major players, namely China, India, Egypt and Ethiopia. A diplomatic format in which the EU shares leadership as a group of states with other non-western powers could be a viable option for

23 The G7 is an association of the western democracies USA, Great Britain, France, Italy, Japan, Germany and Canada. Russia was excluded from the then G8 in 2014 due to the annexation of Crimea.
24 The G20 is the group of G7 countries plus 12 emerging economies and the EU.
25 https://climateaction.unfccc.int

future multilateral relations in various policy areas (Dworkin and Gowan 2019).

A study by the Konrad Adenauer Foundation emphasises agile, unconventional approaches and advocates acting temporarily in new, perhaps shorter-term multilateral coalitions outside the UN on important climate and environmental issues if progress cannot be made within the UN (Philipps and Braun 2020).

Since 2014, representatives of non-governmental organisations (NGOs), companies, private foundations, cities and municipalities have also become not only established but also proactive partners at UN climate conferences. Against the backdrop of often deadlocked negotiations within the UN system, these new alliances can often produce constructive approaches to solutions. The Intelligent Cities initiative, for example, showed that cities with ambitious goals can be a lever on the path to climate neutrality and that they can learn from each other when implementing climate-friendly policies (Tänzler and Schulz 2021).

The task of research in the coming years is to observe which new alliances and which new actors emerge, perhaps also from civil society, and to analyse how they influence environmental and climate policy. In addition, researchers and policymakers should define how existing institutions can be reformed and where new partnerships and institutions can contribute to a stable world order oriented towards sustainability.

2. Polarisation of US domestic politics

After the change of power in the White House in January 2021, expectations for Joe Biden's presidency were very high worldwide. Among other things, he took office with the promise to lead America back onto the international stage. Climate protection and international cooperation were to be prioritised in domestic policy and moved to the centre of foreign policy decisions (Biden 2020). At the beginning of Biden's term in office, things progressed quickly: a return to the Paris Agreement on climate protection and the WHO, the appointment of former Secretary of State John Kerry as special envoy for climate protection and a voluntary commitment to reduce climate-damaging emissions by 50% by the year 2030 and to achieve climate neutrality by 2050. To this end, the White House presented an ambitious climate package and a plan for the massive expansion of wind farms along the East and West coasts.[26]

However, the future durability of these initiatives, such as the climate package, is massively threatened by an increased drifting-apart of the ideological positions of the Democratic and Republican parties in the US (Abramowitz 2018). Thus, a change of power in the White House in 2024 could result in a rapid return to isolationism. The background to this – both in terms of domestic conflicts and foreign policy challenges (see above) – is an increasing erosion of a traditionally bipartisan consensus, which also encompasses many areas of foreign policy, causing the customary, constructive regulatory role in international relations to falter (Böller et al. 2020).

This growing partisan polarisation favours rapid policy shifts in foreign policy and undermines the long-term predictability of the US. To make matters worse, international agreements such as the Paris Agreement on climate change are relatively easy to terminate, while much political capital and bipartisan cooperation is required to negotiate new agreements. Against this backdrop, it should be disturbing news for the international community that US Republicans are currently positioning themselves for the upcoming congressional and presidential elections in 2022 and 2024 (Kagan 2021) through skilfully filling relevant posts and influencing public opinion.

Even though no one currently knows how the elections in 2024 will turn out, there is increasing signs that Trump will run again and that his chances of a renewed presidency are not insignificant (Kagan 2021; Schäfer 2022). The ambitious climate protection goals and environmental projects that Biden has revived in response to Trump's conservative and anti-environmental agenda can only last if the political direction remains steady.

Donald Trump's first 100 days in office in 2017 were enough to overturn 62 environmental laws, reversing many of Obama's key environmental achievements

26 See https://www.whitehouse.gov/climate

(Hejny 2018). These included not only withdrawing from the Paris Climate Agreement, but also moving away from National Climate Assessments and eliminating climate change impacts reviews within environmental impact assessments (Hejny 2018). Similarly, Trump approved controversial pipeline projects and the expansion of offshore drilling. These measures had sometimes more, sometimes less climate diplomacy influence on Europe and Germany. However, they actually and symbolically spoke against the guiding idea of decarbonising the economy and torpedoed existing transformation approaches in the economy and society, which were supposed to be driven primarily by powerful and rich states.

Looking back at the beginning of Donald Trump's presidency – but also to the Republican presidents Reagan and Bush – there are four areas where American environmental policy or its framework were negatively affected by Republican presidents: 1. Appointments of business-affiliated personnel to federal environmental agencies; 2. Significant staff and budget cuts in key environmental agencies; 3. The lack of enforcement of environmental laws; and 4. The appointment of conservative judges who ultimately decide on environmental law and who – in the case of the Supreme Court – are appointed for life (Hejny 2018).

If history were to repeat itself in the event of another change of policy in the USA, there would not only be one less potential environmental pioneer state and promoter of necessary developments, Europe would also lose a partner for international climate and environmental protection efforts and would have to progress without or even against the US (Overhaus 2020).

3. Europe and the Sino-American technology conflict

The global battle for technological leadership between the US and China is in full swing. The People's Republic, which in recent decades has developed from a global workshop with cheap labour into a high-tech location, is striving for technological autonomy under state control with its industrial policy agenda "Made in China 2025" (Shi-Kupfer and Ohlberg 2019). Fearing that China could replace the US as a technological superpower, the Trump administration pursued a "selective decoupling" of the two markets. In addition to imposed diversification of supply chains, tariffs, boycotts and export restrictions, technology transfer was limited by efficient investment controls (Rudolf 2020). The new US administration also sees China as its biggest competitor, with President Biden under domestic political pressure to take action against China. The Republican opposition brands the president as weak and unable to act (Forgey 2021). Against this backdrop, Biden has elevated the rivalry with China to a "contest between autocracies and democracies"[27].

27 Biden said: "I think we're in a contest – not with China per se, but a contest with autocrats, autocratic governments around the world, as to whether or not democracies can compete with them in the rapidly changing 21st century. "(The White House 2021a)

The question of whether a cooperative involvement of the two superpowers will be possible in the future will be central to the solution of global problems such as climate change and the positioning of Germany and Europe.

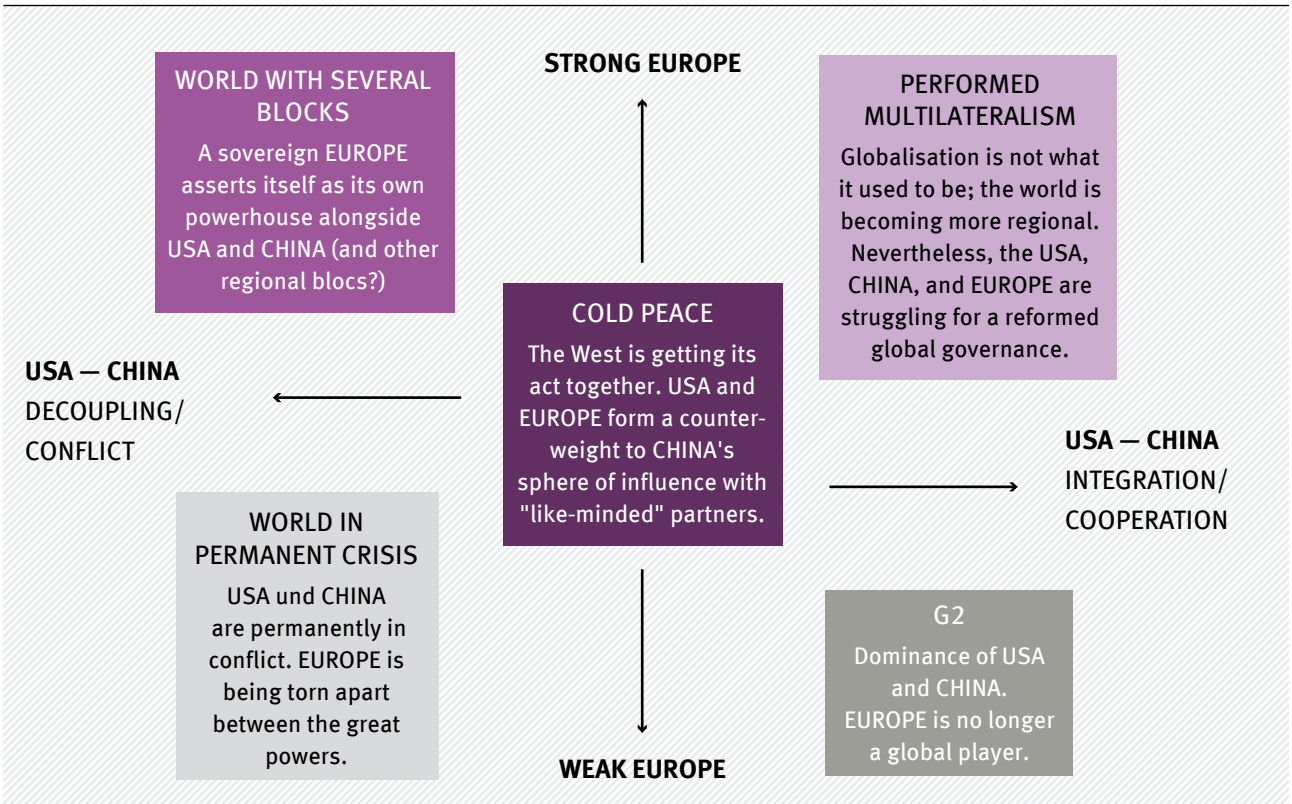
Europe is in danger of being crushed in the Sino-American technology conflict. In order to remain active in the two important markets (US and China) in the future and to be able to play a relevant role in the development of technological, ecological and social standards, Europe must position itself skilfully. Germany and Europe are responding to this challenge with a mix of industrial policy, diversification of supply chains and the expansion of technological sovereignty, for example through the flagship initiative "Trustworthy Electronics" spearheaded by the Federal Ministry of Education and Research (Ziegler 2020). At the same time, the US and Europe are celebrating cohesion on key issues of the future such as standards for artificial intelligence (AI), climate innovation, secure supply chains or cyber infrastructure through their close cooperation in the newly created Transatlantic Trade and Technology Council (TTC) (Barker 2021).

One example of China's technology leadership ambitions is in the area of digitalisation, including the expansion of 5G, the development of artificial intelligence and quantum research. Certain Chinese ICT companies, such as Huawei or Alibaba, are global players, with Europe increasingly falling behind (Shi-Kupfer and Ohlberg 2019).

In response to the question of the future positioning of the EU vis-à-vis the US and China, a number of scenarios are conceivable, depending on Europe's "strength/weakness" and the degree of cooperation between the USA and China (Bartsch et al. 2021): Two of the discussed scenarios describe a strong and capable EU – once in the context of a revived multilateralism ("reformed multilateralism"), another time in the area of tension in which the superpowers confront each other ("world with several blocs"). A

Figure 05

Five scenarios on the future role of the EU



Source: Bartsch, B.; Laudien, A.; Sprich, C. (2021): Globalisation scenarios. Challenges and options for action from the perspective of German business. Bertelsmann Stiftung. https://www.bertelsmann-stiftung.de/fileadmin/files/user_upload/Globaliszenario_2021_2final.pdf. Status: 06.01.2022.

third scenario describes a permanent Sino-American conflict in which the EU is worn down ("world in permanent crisis"). Scenario Four envisions a world in which the two superpowers dominate side by side and develop common interests as partners ("G2"). The fifth scenario ("Cold Peace") represents a continuation of today's status quo. The scenarios show alternative images of the future that can serve as points of reference for the formulation of political strategies.

China's influence on digital infrastructures in Europe has consequences for a wide range of policy areas. This includes security policy, but also environmental policy, e.g. in the context of testing smart cities, because smart cities use cloud solutions and "Internet of Things" technologies to support urban administrative tasks such as traffic management, waste management and environmental protection measures (Shi-Kupfer and Ohlberg 2019). Chinese companies such as Huawei offer these solutions and could – at least in theory – collect data from European citizens and use it for themselves and their own technological advancement. Numerous agreements have already been signed between various European regions and cities and the company Huawei for smart city pilot projects, and Europe has so far failed to evaluate the risks associated with tech giants interfering in smart city concepts (Shi-Kupfer and Ohlberg 2019). There is a need for further research, e.g. on the impact of these collaborations on the development or use of environmental technology in China.

Conclusion for environmental policy and research:
The world disorder, which is reaching a new peak with Russia's war of aggression against Ukraine, poses a threat to our Western values and the democratic part of world society. Defending these values and democracy requires swift action and resources at different levels. However, these levels – the nation-state, but also sub- and supranational levels – are increasingly under pressure. The polarisation of US domestic politics and the potentially resulting societal instability naturally have an impact on the foreign policy role that the US can take. The ability to act quickly – whether with regard to national or international climate and environmental policy can suffer if foreign policy positions are uncertain.

The question of resources to be used in the fight against climate change is also increasingly shaped by world disorder. The rivalry between China and the US for technological leadership influences which technologies prevail where in the world and how they are compatible with environmental and sustainability goals. Europe and Germany still have to find their role here and, if necessary, review historically grown dependencies.

Above all, however, world disorder has massive implications for future climate and environmental policy: climate change represents a global phenomenon that can only be fought globally through international efforts. However, international climate policy based on negotiation and agreement is threatened by the current world disorder, the future development of which is difficult to predict. International organisations are also coming under pressure more and more. For some years now, other actors and alliances have been taking their place (e.g. of the UN). They are often acting faster and more agile and are able to push processes forward more easily (e.g. Intelligent Cities Initiative). In the future, it will be the task of environmental policy both to build new powerful partnerships or to participate in them, and to reform old institutions.

2.9 Opinion forming in the digital age

Trend: The spread of digital technologies is accompanied by a comprehensive change in the public sphere. Digital media and their underlying algorithmic processes are influencing public discourse and opinion forming, which play a central role in democratic societies. Among other things, "classic media" (e.g. newspapers) are losing importance, new channels are gaining relevance and the sender-receiver relationship is becoming a two-way sender-receiver-sender relationship. The resulting dynamic follows new rules and brings challenges, also for political communication.

Emerging Issues:

- Influencers influence the formation of opinion
- Algorithms influence opinion forming and opinion organisation
- Personalisation and medialisation influence political discourse

In a nutshell:

- Digital technologies can lead to a shift in importance away from the classic media towards so-called media intermediaries, such as Google Search, YouTube, WhatsApp, Twitter, Facebook etc. These new players challenge the established role allocation of the traditional media. They change communication behaviour in society and influence the opinion-forming process as a whole, which also has political implications.

- With the increasing importance of social media, influencers are playing more and more of a role in the (political) opinion-forming process. Algorithms also increasingly determine what content media consumers see. Extreme opinions and hyperactive users reinforce this tendency and contribute to the fact that false news spread faster than fact-based news. What is more, digitalisation opens up new possibilities to reach people in a targeted way. In addition to individualised advertising, (very) small target groups are addressed with tailored election advertising during the election campaign, while information seekers are only shown content that conforms to their opinions.

- The formation of opinion in the digital age is also changing the discourse on environmental issues. For example, on the one hand, disinformation about climate change or environmental policy actors can be spread quickly and specifically in digital media; on the other hand, however, new communication channels are opening up for environmental policy and research. Influencers, for example, offer new opportunities to promote target group-oriented communication on environmental issues.

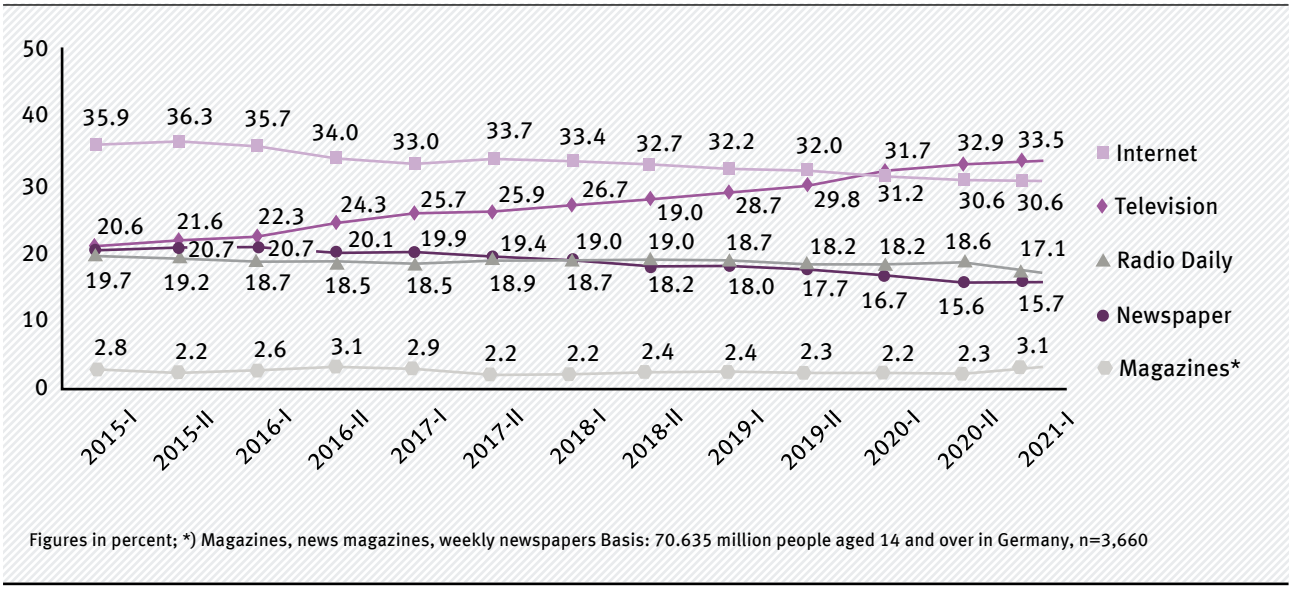
Background:
The current transformation of the media is bringing about considerable changes in the social and political fabric. In view of this development, the question arises as to how democracy and the rule of law are possible in a digitalised society in which formerly significant media are losing relevance. Communication, information and subjectivity are changing enormously and political actors as well as global companies are pursuing their communicative interests much more and actively by means of new, digital tools (Universitäts- und Stadtbibliothek Köln 2021).

Political decision-making processes and the free and individual formation of opinion necessary for it play a central role in democracy. In an opinion-forming process, citizens form an opinion on how the society in which they live should be shaped and which political decisions they support or reject. The guiding principle is that the opinion-forming process should include as many different perspectives as possible, representing all the different life situations that exist in society. Since pluralism is an essential principle of democracy, it is a declared goal of democratic media policy to prevent the concentration of opinion power with certain individuals or groups – be they state or non-state (Hasebrink 2016).

The formation of opinion through classic media loses importance
Media and politics as well as media and power have always had a special relationship to each other. Digitalisation is leading to a structural change in the public sphere that is as disruptive as the introduction of the printing press (Baecker 2018). New digital technologies lead to new communication behaviour. For example, the importance of the various media that people use in their everyday lives to inform themselves about current events and to form opinions is currently changing massively (see Figure 5). New platforms and so-called intermediaries – social networks such as Facebook, Twitter, Instagram and TikTok, platforms such as Google Search, YouTube and communication channels such as WhatsApp and Telegram – are challenging the established role allocation of the classic media (Hasebrink 2016). Information about this is provided, for example, by the "media weighting study", a representative survey to calculate the power of opinion across different media (die medienanstalten – ALM GbR 2021b). The use of the internet as a source of information continues to increase, with the relevance of the internet growing most strongly among 50–69 year olds.

Figure 06

Shift in opinion weighting of different media



Figures in percent; *) Magazines, news magazines, weekly newspapers Basis: 70.635 million people aged 14 and over in Germany, n=3,660

Source: die medienanstalten - ALM GbR (2021): Mediengewichtungsstudie. https://www.die-medienanstalten.de/themen/forschung/mediengewichtungsstudie. Status: 25.01.2022.

This shift has numerous implications: The old sender-receiver relationship (broadcasting approach) becomes a two-way sender-receiver-sender relationship in which politicians and other users no longer "go on air" and send messages to clearly defined, demographically determined target groups and citizens react passively (Kelber 2013). Instead, citizens have a more active role: they express their opinions (e.g. through comments) and reproduce the opinions of others (Futurium gGmbH 2021). In addition, completely new possibilities have emerged to destroy one's political image (Kelber 2013). Thus, "media gaffes" or their treatment by the media can destroy entire careers overnight.

Emerging Issues:

The current discourse on the change in opinion formation, the role of established and new media as well as the power of new players is diverse, dynamic and complex and is also relevant from an environmental perspective. The influence of influencers on opinion formation, algorithmically organised opinion formation as well as personalisation and medialisation in political discourse are related to communication about environmentally relevant topics and their discourse in society.

1. Influencers influence the formation of opinion

In addition to peer orientation, the influence of influencers on individual consumption preferences is particularly relevant in the 14–19 age group and will probably continue to increase in the future. An analysis by Werg and Cerny (2020) showed that the most successful German influencers spread insights into strongly materialistic lifestyles and none of the ten largest accounts promote sustainable content, ideas or products. In 2018, half of 14–19 year-olds said they had bought a product or service in 2017 because influencers, bloggers, YouTubers or celebrities had promoted it (Statista GmbH 2018[28]; Werg and Cerny 2020).

There are also influencers who use their reach to address social or sustainable issues ("sustainability influencers"). However, these accounts have a much smaller reach compared to the largest German influencer accounts, e.g. footballer Toni Kroos

with over 35 million followers on Instagram[29]. For example, the ten biggest influencers on the topic of veganism only have between 193,000 and 611,000 followers (Statista GmbH 2021). One possible explanation is that young people who are already socio-ecologically oriented are less online overall and spend less time on social media (Werg et al. 2021).

The YouTubers Rezo (1.75 million followers on YouTube) and maiLab (1.46 million followers on YouTube) are currently among the best-known and most-discussed examples of using one's own reach to inform followers in a scientifically sound manner and to motivate them through their own commitment to political initiatives.

Many of the "sustainability influencers" operate in the area of tension between consumption and sustainability. They also have a business model that is based on cooperation with companies, namely to promote the consumption of products. The focus here is on sustainable products, but the brands with which they cooperate are at the discretion of the influencers, who assess this in terms of preserving their credibility (Kolb 2021). On the positive side, "sustainability influencers" use their reach to share non-materialistic content, for example through instructions and instructional videos on how to repair or make consumer goods (Benecke 2019).

28 More recent figures are not available.
29 Status 2022

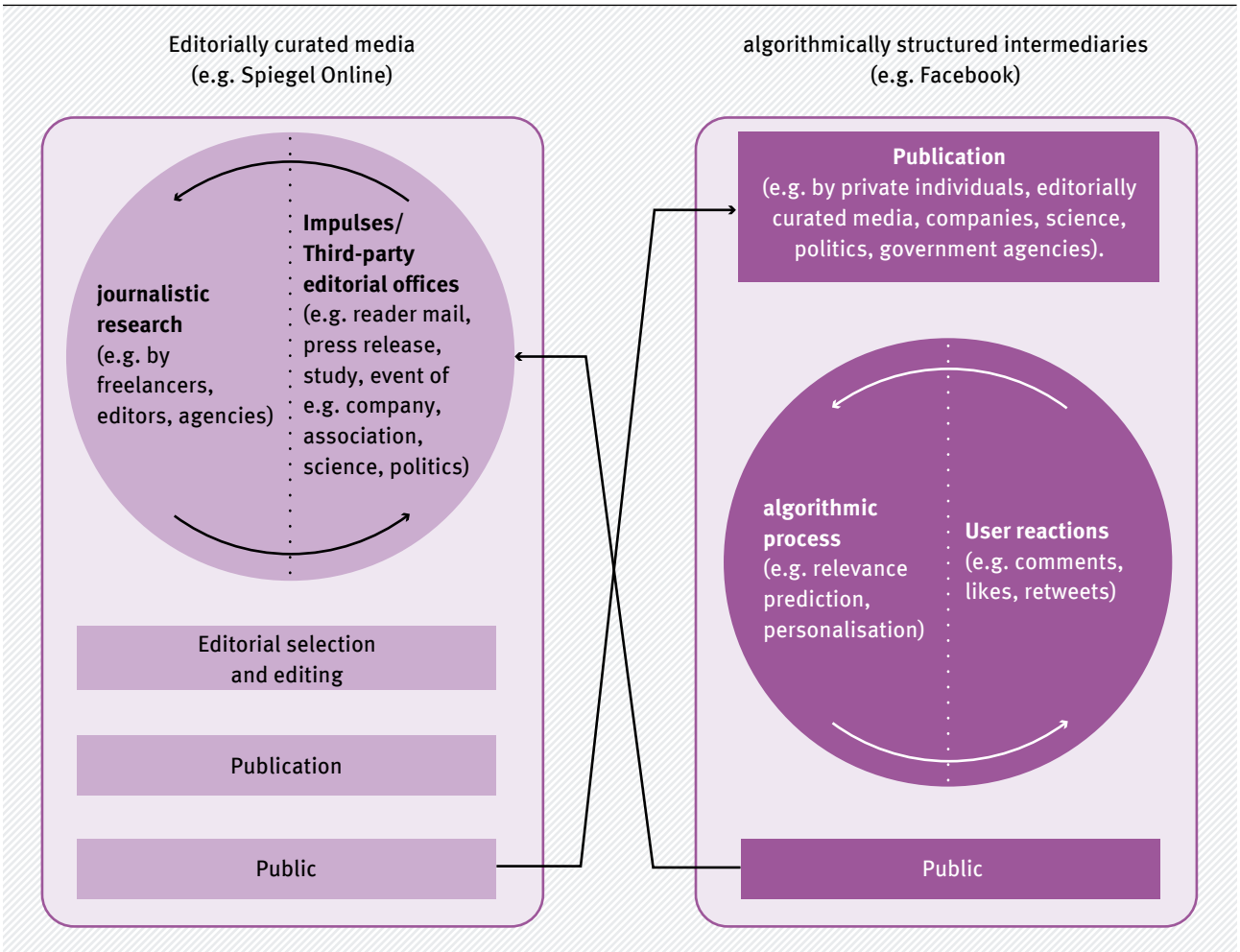
In this way, they spread the concept of sustainable lifestyles with a focus on sufficiency and a reduction of consumption. In addition to the classic multipliers in the field of environmental education, such as public institutions and civil society associations, "sustainability influencers" now also act as multipliers who educate people about sustainability and environmental protection.

2. Algorithms influence opinion forming and opinion organisation

Intermediaries such as social networks, instant messaging services, search engines or video portals have become the central place of online communication and information behaviour (die medienanstalten – ALM GbR 2021a). They mediate between private individuals, journalistic-editorial media, companies, politics and administration. Google Search, Facebook, YouTube, WhatsApp etc. usually distribute content created by third parties and reassemble it based on the assessment of its relevance for the user. They use algorithmic decision-making processes to assess relevance. They predict the potential demand for a specific content and adjust the placement and presentation of the content according to the prediction. That way – and more strongly than editorial media – they assess the relevance of content based on the immediate reaction of the audience (e.g. through comments, likes and re-tweets, see Figure 6). Consequently, they are able to make corresponding personalised media available (Lischka and Stöcker 2017, p. 16f.).

Figure 07

Organisation of an algorithmically structured public sphere



Source: Lischka, K.; Stöcker, C. (2017): Digital public sphere. How algorithmic processes influence social discourse. https://www.bertelsmann-stiftung.de/fileadmin/files/BSt/Publikationen/GrauePublikationen/Digitale_Oeffentlichkeit_final.pdf. As of: 25.01.2022. doi:10.11586/2017028.

Intermediaries are thus becoming important gatekeepers who tap content from numerous sources, filter it by means of algorithms and combine it to make personalised information available (die medienanstalten – ALM GbR 2021a).

Only a small percentage of social network users really post regularly. About 5% are very active and belong to the so-called hyperactive users. Yet these few dominate the debate as algorithms amplify their reach. Thus, 5% of users are responsible for 25% of all interactions. Algorithms reward interaction – and so, for example, tweets that have a particularly high number of interactions become particularly widespread and then have a strong effect on the algorithm itself (Futurium gGmbH 2021).

The new, central role of user reactions and algorithmic processes becomes clear in the comparison of the two publicity trajectories between editorially curated media and algorithmically structured intermediaries (see Figure 6). In the latter case, user reactions determine the distribution of attention via intermediaries such as social networks, instant messaging services and search engines. What is new about this is that the reactions of users and the automated decision-making processes of algorithms (ADM processes) do not follow a linear causal logic (Lischka and Stöcker 2017).

Media content personalised in this way contributes to a distorted picture of opinion, as it mainly shows users content that corresponds to their own political world view (filter bubbles). The user's own world view is reinforced; other views that are not familiar are filtered out and ignored (Landesjugendring Thüringen e. V. 2020).

Platforms are designed so that users spend as much time as possible on them and interact with the content. Users are shown content that they are likely to respond to. This allows the algorithm to learn more about individual users, serve more appropriate ads and generate more ad revenue. The incentives are built in such a way that users spend a lot of time on the platform, but only briefly and superficially engage with the content. The reason behind this: The more often the content is changed, the more advertising can be displayed (Futurium gGmbH 2021).

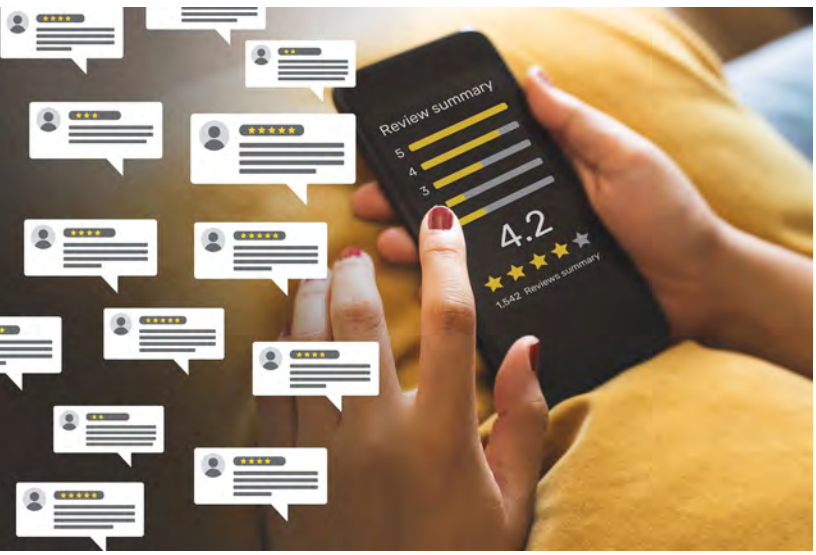
Fake news spread faster than true news: In editorial media such as newspapers, radio and television, journalists are gatekeepers who distinguish reliable from dubious sources. To the extent that content can be produced by anyone, it becomes increasingly difficult to check the truthfulness of content – and the amount of fake news increases. It is interesting that false news spread six times faster than true content on Twitter, for example (Vosoughi et al. 2018). "With the increase in reach, dissemination speed and information density of the media, not only the possibilities of media-mediated shaping and perception of reality expand, but also the dangers of collective deception (manipulation)" (Sarcinelli 2021).

The trends described above lead to a reinforcement of predefined opinions and a fragmentation of the public. With regard to climate change, this is problematic because it requires broad support in society to implement the necessary measures for a transformations towards (more) sustainability. If false information is spread, such as climate change does not exist, both personal willingness to adopt sustainable lifestyles and support for political action decline (van der Linden et al. 2017; Cook 2019). A recent example of rapidly spreading false information is the narrative of the alleged threat of a climate lockdown, i.e. government-imposed bans, such as driving bans, to protect the climate. This false narrative has been disseminated by right-wing media and opinion makers (Maharasingam-Shah and Vaux 2021).

Intermediaries such as Facebook and YouTube have been slow to react. Although the YouTube algorithm has been found to recommend little disinformation, it also provides little in-depth information on climate change (Schmid and Allgaier 2021). There are a large number of ads on Facebook that deny or distort climate change; a recent study identified 113 such ads viewed 10 million times over a ten-month period. A large proportion of these advertisers were reported to Facebook a year earlier, but no steps have been taken to fact-check the paid posts (Buchan 2021a). In addition, only a small minority, about one-fifth, of posts spreading disinformation about the climate crisis are fact-checked by Facebook (Buchan 2021a). Intermediaries have some leeway to block false reports. In some cases, platforms such as YouTube or Twitter delete user accounts of opinion makers, for example climate change deniers, if it is proven that they spread false information. Google also offers a fact-checking function that allows users to get information about the source and to see a second opinion about the website and the topic (Hebbar 2022).

3. Personalisation and medialisation influence political discourse

The medialisation of politics means that the logic of the media "spills over" into the realm of politics and that, for example, journalistic calculations for generating public attention are transferred to politics (Kelber 2013). Politics increasingly makes use of media services and becomes more dependent on them (Sarcinelli 2021).



Today, the internet is more than just a new channel through which press releases can be disseminated. The upheaval in the media world is so profound that politicians and policymakers now move through the public space in a completely different way than they did just a few years ago (Kelber 2013). For example, candidates in the 2021 federal election in Germany have significantly expanded their social media activities compared to the 2017 election (Schmidt 2021). Following this logic, it is becoming increasingly important for political actors what is spectacular and attracts public attention (Kelber 2013).

With increasing individualisation and the disappearance of "standard life courses", purely demographic characteristics such as age or gender are less and less meaningful in terms of the situation people find themselves in, who they are and what they want. Politicians no longer deal with homogeneous, stereotypical groups of voters, and in election campaigns they think very carefully about who they address and how. They further professionalise their communication by bringing social media experts and data scientists into their teams, who systematically analyse large amounts of data and online reactions, build professional social media presences for them and adapt online political communication to the anticipated reaction of the users (Kelber 2013). Microtargeting can be used to direct personalised messages to voters via social media (Futurium gGmbH 2021).

Similar to how society is becoming more and more differentiated, political discourse is also becoming more differentiated and fragmented. With the increase in diversity of opinion, the discourse is also becoming more confusing. In addition to time-honoured political behaviour such as voting or demonstrating, hacking and leaking are increasingly becoming means of interfering in political events. Leaking and whistleblowing are becoming increasingly relevant due to large amounts of digital data and, in the case of leaks, rapid dissemination via the internet, thus creating new power relations. Unauthorised information is published and also used by investigative quality journalism (Futurium gGmbH 2021).

With communication in digital media, politicians increasingly have the opportunity to target groups

of voters. The aforementioned microtargeting allows politicians to position themselves on environmental issues to their potential voters. Some voters can be promised strict environmental rules, while other voters can be addressed with a different focus (Dachwitz 2017). Politicians are hardly bound by regulations when posting on social media: Facebook, for example, has so far excluded fact-checking of politicians, even though they have a proportionally high interaction rate. Posts by politicians with disinformation about climate change are not checked by the Facebook Climate Science Center or by third parties commissioned by Facebook (Buchan 2021b). On the other hand, there are also improved opportunities and lower barriers for multipliers to reach their audience on environmental issues. An individualised approach can strengthen the effectiveness of environmental communication if it is communicated via online media and social network platforms and, for example, the everyday relevance for adolescents and young adults is specifically emphasised (Hasebrink et al. 2021).

Conclusion for environmental policy and research:
The dynamics described in opinion formation in the digital age have great significance for a topic that affects society as a whole, such as environmental protection. Algorithms are not tuned to direct the focus to socially important topics such as climate change, but to posts that are adapted to the respective reader and promise a high interaction rate.

Multipliers also increasingly influence individuals in their opinion formation when they want to reduce the willingness to act and the social consensus for measures to combat climate change and disseminate targeted posts with disinformation about climate change in digital media. This can change the social mood and thus openness for environmental issues and reduce the scope for action of environmental policy. It is therefore important to check misinformation and to specifically label it as such, and to strengthen independent and fact-based journalism. The UBA and BMUV can support this by quickly providing scientifically valid data and studies and by making it easier for journalists to research environmental issues.

In addition, new opportunities and avenues are opening up for research and environmental policy, because research results on environmental topics can be communicated to citizens through microtargeting. For this, new channels such as influencers or other formats are used, which can potentially increase approval for necessary environmental protection measures.

2.10 The future of city centres

Trend: The image of city centres is changing in many places. For a long time, the "traditional" use was strongly characterised by retail, but due to the increasing shift of consumption to digital spaces, there is less and less demand for inner-city retail. At the same time, high rents are a burden on commercial and private tenants, so that living in the city centre and many city centre business models are no longer profitable.

Emerging Issues:

- Functional change of city centres
- Spatial redevelopment of city centres
- City centres as part of spatial networks

In a nutshell:

- City centres are constantly changing under the influence of a variety of factors. The Covid-19 pandemic has accelerated some of the ongoing developments, such as the crisis in bricks-and-mortar retail, the rise of home office and its impact on city centre workplaces, new challenges from increasingly expensive housing and the need to adapt to climate change. However, it is unclear which changes will be of long-term duration.

- The functions that city centres fulfil for their inhabitants, such as consumption, tourism or living and working, are changing. A functional shift goes hand in hand with the redesign of inner-city spaces, so that new appearances of city centres can emerge in the future. Embedded in their urban surroundings and regional environments, city centres form nodes in changing networks between city districts, suburban locations, rural areas and other cities.

- The pressure for change to which city centres are subject harbours both opportunities and risks for their further development into sustainable living spaces. In this current phase of reorientation, environmental policy actors have the opportunity to take fundamental steps in order to make city centres more ecological and sustainable. Fields of action can be, for example, the re-greening of urban areas and the creation and upgrading of urban green infrastructure as well as the design of inner-city mobility and traffic areas.

Background:

The inner city is often the centre and historical core of a city (Ruess et al. 2021; Vrhovac et al. 2021). As such, it often features historically and/or culturally significant buildings and is an expression of the individuality of cities. However, there are no cookie-cutter city centres. Central European and German city centres are in fact very different. They are not only the meeting point of supply and traffic routes, but are above all characterised by a mixture of uses and diversity: Retail, tourism, culture, housing, work – to

name just a few examples that make up the narrow space of city centres (Raphael et al. 2021).

City centres are subject to permanent change. Since the mid-2000s at the latest, the term "desolation" has been used to describe this (Hatzfeld and Weis 2021). City centres have been increasingly characterised by retail migration, ageing pedestrian zones and traffic routes, and decreasing diversity in the hospitality sector. Especially under the influence of the Covid-19 pandemic since March 2020, it has become clear that this ongoing transformation process can permanently change the appearance and use of city centres.

The effects of the Covid-19 pandemic, especially the weeks-long closures of shops, restaurants, cultural institutions, etc. - including the lockdowns in spring 2020, autumn and winter 2020/2021, as well as further infection control measures - were particularly evident in city centres (Adam and Klemme 2020) and are likely to occupy municipalities for years to come (Bunzel and Kühl 2020).

A variety of influencing factors put city centres under pressure

In addition to the Covid-19 pandemic, the duration and outcome of which are not yet foreseeable, city centres are changing above all due to demographic pressure (influx of young people, social heterogeneity, etc.), advancing digitalisation and the associated increase in online trade, as well as the changing financial, land and real estate markets – and finally also the already noticeable consequences of climate change. However, the interplay of these and other factors varies between city centres, hence individual developments can initially only be depicted at an abstract level.

City centres have developed into sought-after residential locations for young people over the past ten years (Grundmann 2021). However, attractive residential locations also lead to rising prices and rents due to their limited supply of (residential) space. Therefore, commercial rents in particular are only affordable if sufficient turnover can be generated, and residential rents only if household incomes are sufficient.

The retail sector, and increasingly the restaurant sector as well, are suffering from the consequences of digitalisation. Consumption is increasingly shifting towards online retailing (Tromp and Kossok-Spieß 2021) and gastronomy is also changing under the influence of digital business models. In the course of the Covid-19 pandemic, take-out and delivery services gained importance for restaurants and shops, so that there is now strong competition here (Marx 2021; Statista GmbH 2021). The changes in the use of office space due to the shift of the place of work to people's homes as a result of the increase in mobile working or home offices (see Chapter 2.6) is also an effect amplified by the Covid-19 pandemic that affects the use of inner-city real estate.

Changed city centre images due to decline in retail trade

As a consequence, it can be assumed for the near future that the already noticeable sight of empty shops in city centres will increase, the number of visitors will continue to decline and the general appearance of the buildings will continue to deteriorate. However, it is currently not possible to make a reliable statement on the number of retailer insolvencies; rather, it can be assumed that the temporary suspension of the obligation to file for insolvency as well as state support payments prevent insolvency in the retail sector or at least postpone it to a later point in time (Enkelmann et al. 2020; Federal Ministry of Justice and Consumer Protection 2021). At least currently, there is no discernible increase in insolvencies in the retail sector (Federal Statistical Office [Destatis] 2021). Nevertheless, the underlying fear that many shops could "die" eventually is being expressed (Podjavorsek 2020; Süddeutsche.de 2020; Hielscher and Ramthun 2021) and considerations are being made accordingly about the necessary political support (SynVer*Z – Synthese- und Vernetzungsprojekt Zukunftsstadt et al. 2020; Raphael et al. 2021). An interesting dichotomy is likely to form in which, on the one hand, rents for residential and commercial space in city centres reach a high level, but, on the other hand, the attractiveness of city centres and, consequently, the willingness to pay for rents could decline.

What can the city centres of the future look like?

For some time now, politicians have been trying to tackle the challenges facing city centres with different approaches. These include, for example, the "Inner City Strategy" of the Inner City Advisory Council at the Federal Ministry of the Interior, Building and Community (Bundesministerium des Innern, für

Bau und Heimat [BMI] et al. 2021) and the related funding programme "Sustainable Inner Cities and Centres" (Federal Institute for Research on Building, Urban Affairs and Spatial Development [BBSR] 2021). Various projects have already been funded since 2016 as part of the interdepartmental Innovation Platform Future City (IPZ) (Federal Ministry of Education and Research [BMBF] 2018). However, the design of city centres is not only a (municipal) political task, but also requires the commitment of economic and social actors. As diverse as city centres are in Germany, they can be (re)designed in a variety of ways in the future, characterised, for example, by a resilient building culture, a symbiosis between the movement of people and goods, and an integration of digital projects into the environment (cf. e.g. Riechel 2021, Syn. Riechel 2021, SynVer*Z – Synthesis and Networking Project Future City 2021 or Vrhovac et al. 2021).

Emerging Issues:

City centres are currently changing rapidly. Some of these changes were caused by the Covid-19 pandemic, some started before and were intensified by the pandemic. City centres can rarely be considered in isolation, but are often embedded in the processes of change in other parts of the city as well as the surrounding area, e.g. in mobility changes or the transformation of food supply and commodity supply chains.

1. Functional change of city centres

City centres fulfil several functions such as consumption, work, but also living and recreational space, culture and education, politics and administration, etc. for their inhabitants. City centres are therefore often the face of a city and at the same time a place to live and work, a transport hub and a meeting place, with a high density of buildings in a spatially limited area. Even before the Covid-19 pandemic, there were numerous approaches to revitalise city centres through mixed and intermediate use. However, the restrictions enforced in the course of combating the pandemic have led to an increase in these concepts in order to, among other, compensate for a drop in turnover, provide new design impulses and meet social needs.

Concepts of mixed use combine, for example, residential and office buildings with retail space, gastronomy or cultural spaces, but in any case require cooperation between property owners, investors and municipalities (Fiala 2021). A network funded by the Bavarian State Ministry of Economic Affairs, Regional Development and Energy[30] is

30 Network partners are: Handelsverband Deutschland (HDE), Deutscher Städtetag (DST), Deutscher Städte- und Gemeindebund (DStGB) as well as the Bundesvereinigung City- und Stadtmarketing Deutschland (bcsd) and CIMA Beratung + Management GmbH.

currently developing a database[31] that provides an overview of innovative urban development concepts. Inter alia, the database addresses environmentally relevant topics, ranging from mobility to urban design. The mobility category includes, for example, projects that offer sustainable delivery services or digitalised public transport tickets, while in other cities the quality of stay and urban nature have been upgraded (Stadtimpulse 2021).

Interim use is also a concept to reduce vacancies in real estate. New users with new ideas, such as concept stores or pop-up stores, or cultural initiatives enable entrepreneurs and artists to test their products and services or art objects at low financial cost (Handelsblatt GmbH 2021). A characteristic of interim use is that it develops in an agile manner. This became particularly clear during the pandemic-related restrictions in gastronomy and retail. If interim use concepts are supported by cities, cityscapes can change more frequently and dynamically in the future.

When cities are functionally redesigned with a focus on mixed and intermediate use, this can also have a positive impact on the environment. A city of short distances is conducive to active mobility, giving people a greater incentive to walk or cycle. The beneficial effects on the environment compared to private motorised transport is obvious – no greenhouse gases are emitted and there is no air pollution (Federal Environment Agency (UBA) 2017). The central issue is therefore how the space in the city centre is distributed, for example, what proportion of the space is used for motorised traffic or for cycle paths or footpaths, or how many (green) spaces are set aside for recreation and leisure. During the Covid-19 pandemic, the importance of these measures increased further, as new needs emerged such as the desire for alternatives to public transport and thus the expansion of bicycle paths, as well as for areas for outdoor recreation and exercise.

In the case of temporary use of retail space, additional sustainability criteria can be applied. In Bremen, for example, a fair and sustainable department store was given a building in the city centre for a certain period of time: Among other things, it convinced its competitors with its overall sustainable concept (WFB Wirtschaftsförderung Bremen GmbH 2020). In this way, municipalities can potentially actively shape interim use solutions and promote inner city attractiveness with high environmental qualities.

2. Spatial redevelopment of city centres

City centres are usually a highly dense mix of buildings and – paved – open spaces (Riechel 2021, p. 6). Their transformation is not only taking place under the influence of digitalisation as well as demographic changes, but also additionally under the influence of climatic changes and increasing urbanisation. Since the available space in city centres is limited, construction measures are necessary, for example the addition of new storeys to buildings, the greening of rooftop surfaces and facades, or the reallocation of public spaces such as traffic routes (Riechel 2021, p. 19 ff.). Due to the crisis resulting from the Covid-19 pandemic, public space has become a field of experimentation in many places, where various approaches to solutions have been implemented, such as the dismantling of transport infrastructures or the reallocation and renaturation of land (Riechel 2021, p. 34). In the future, spatial redesign is also likely to be reflected in new architecture. Depending on the necessary requirements and functionalities in demand (see above) as well as the buildings that are already there, it will produce new facades and interiors adapted to climatic conditions. Here, too, it is conceivable that public spaces as well as interiors must be adaptable to dynamically changing uses, i.e. that they can be redesigned flexibly and at short notice, for example, without the need for long-term planning processes and cost-intensive measures.

The spatial redesign of city centres also offers possibilities for environmental protection. Whether areas are used as concrete car parks or green open spaces – the type of use has a direct impact on the urban climate as well as indirectly on behavioural incentives for people. In general, the control of mobility infrastructure and traffic areas in city centres is an important factor for creating more environmentally friendly city centres (Umweltbundesamt [UBA] 2017). The pop-up bicycle

31 Available at: https://unsere-stadtimpulse.de

lanes that emerged during the Covid-19 pandemic, for example, have led to a slight increase in cycling in cities (Kraus and Koch 2020). Consideration is now being given to how and whether these pop-up cycle paths can be perpetuated, as an increase in cycling is advantageous for both human health and air quality (Götting 2021).

The aforementioned re-greening of urban areas would also be beneficial in terms of increased climate resilience (German Advisory Council on the Environment [SRU] 2018). Urban green spaces contribute to air pollution control and have a regulating effect on the urban climate. They lower the ambient temperature, increase humidity and are thus also an instrument of climate adaptation, e.g. in the event of heat waves (Mattanovich et al. 2017). However, it is important to ensure that urban trees are preserved in times of climate change. They often suffer from changes in precipitation as well as heat and drought periods. Planting so-called climate trees as well as developing rainwater management and tree pit design are possible instruments to adapt the trees to the changing conditions (Dickhaut and Eschenbach 2019). Green roofs and facades are additional measures that regulate the microclimate and improve air quality (Brune et al. 2017). Due to the cooling effect on the immediate surroundings, they can also increase the energy efficiency of a building (Brune et al. 2017). Furthermore, birds, insects and other animal and plant species benefit from greening these areas (Schmauck 2019). With regard to heavy rainfall events, urban water management benefits from green areas, because of the water-retaining ability of green spaces and city centres are less dependent on grey infrastructure (German Advisory Council on the Environment [SRU] 2018). In this context, the concept of the sponge city is currently being promoted against the background of heavy rain and heat precautions. In this context, the city should absorb water like a sponge, e.g. through decentralised infiltration, green spaces, green roofs, and release it again during heat waves or dry phases, e.g. through evaporation or from reservoirs for irrigation (Bavarian State Ministry for the Environment and Consumer Protection [StMUV] 2020).

3. City centres as part of spatial networks

Functional and spatial redevelopment of city centres are mutually dependent. It is therefore understandable that changes in city centres cannot

be viewed in isolation from developments in the other parts of the cities or beyond city boundaries. The transformation of city centres is a social, economic and political task. Since city centres are in a variety of exchange relationships – transport infrastructure, digital infrastructure, energy and water supply as well as waste disposal infrastructures with other parts of the city such as neighbourhoods, commercial areas and their surrounding areas (surrounding municipalities, other cities, metropolitan regions) - they are also affected by change processes beyond the city centre. Therefore, integrative approaches of urban development policy are summarised under the guiding principle of urban development oriented towards the common good (Federal Ministry of the Interior, Building and Community [BMI] 2020). In the future, they are likely to determine the transformation of city centres in their respective spatial networks.

These integrative approaches offer starting points for realising the concept of a green city with a high environmental quality. For example, city centres can improve protection against extreme weather events by promoting the preservation or renaturation of interconnected green and blue infrastructures in close exchange with the surrounding area (Federal Ministry of the Interior, Building and Community [BMI] 2020). Urban transport cannot be viewed in isolation from the surrounding area either, especially with regard to the flow of goods and commuter traffic. New mobility concepts that link the city and the surrounding area, e.g. park-and-ride stations, can create incentives to reduce commuting and thus also the volume of traffic in the city (Umweltbundesamt

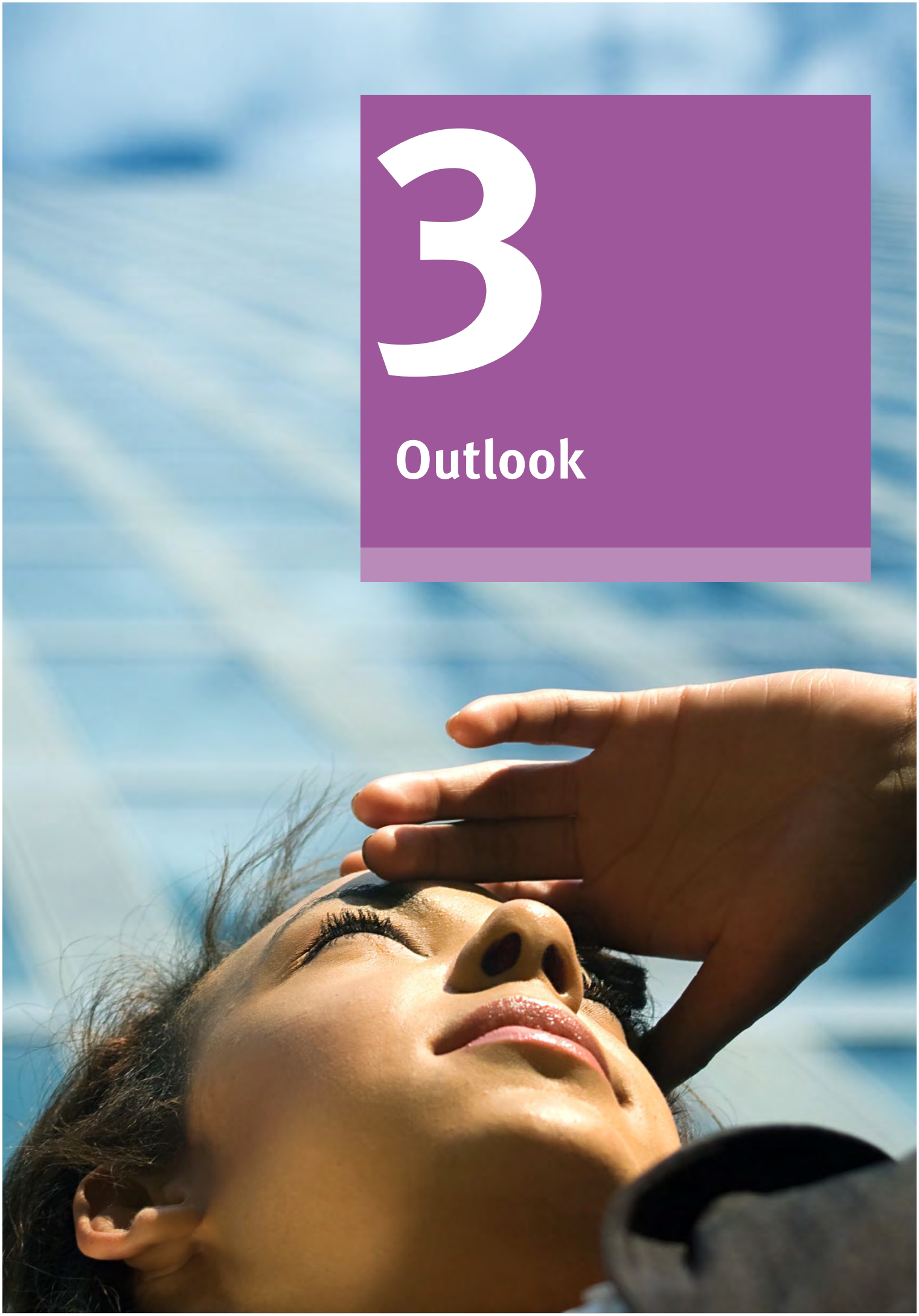
[UBA] 2017). Innovative concepts such as mobility hubs serve to avoid long transport routes and promote regional material flows. After all, if delivery routes are optimised and organised in a decentralised manner and environmentally friendly transport options are increasingly used, inner-city traffic can be relieved. The shift of resource-efficient and low-emission production back to the inner city, through increasing urban production or even urban agriculture, also offers potential to rethink the role of the inner city within spatial networks and to use the transformative potential in terms of environmental protection (Vrhovac et al. 2021).

Conclusion for environmental policy and research:
City centres are continuously changing. However, not least the Covid-19 pandemic has increased the pressure for change and created windows of opportunity in which a further development of city centres towards sustainable living spaces becomes possible. In this current phase of reorientation, environmental policy actors have the opportunity to take fundamental steps in order to make city centres more ecological and sustainable.

Thus, a spatial and functional redesign of city centres can provide potential benefits for the environment. Important factors here are the re-greening of urban open spaces and the creation and upgrading of urban green infrastructure, including green roofs and facades. Mobility management that creates incentives for a transformation away from motorised individual transport towards active mobility and public transport is also central. However, it should be kept in mind that the development of integrated sustainable solutions costs time and money and that city centres are currently under great pressure to develop solutions quickly due to the effects of the Covid-19 pandemic. For environmental policy, however, this also creates the potential to actively (co-)shape city centres and to provide impulses and scope for action. The crisis has not only intensified the problems and challenges of city centres, but has also triggered a dynamic to develop new and sustainable ideas and solutions and to implement them within a short period of time. The UBA and BMUV can support this by researching existing good practice examples of city centres and financially supporting new concepts. Furthermore, the communication of these pioneering concepts is crucial in order to publicise how cities in transition can make their city centres more resilient and ecological.

3

Outlook



3 Outlook

The future topics presented in this report have been identified and elaborated in the context of two surprising and powerful developments. First, the occurrence of the Covid-19 pandemic influenced not only the process itself – for example, through the shift to largely mobile work – but also the development of the themes identified and ultimately selected as environmentally relevant. Then, in the phase of the final elaboration of the future topics, the next event occurred with the Russian war of aggression against Ukraine, which influenced some of the outlined developments and partly required adjustments in content.

The methodological basis of the process – horizon scanning – has already been presented at the beginning of the report (see Chapter 1). The purposes that horizon scanning fulfils for the UBA and BMUV by presenting the future topics in this report are summarised below:

- **Emerging issues can be identified, discussed and dealt with.** These are topics that are novel and environmentally relevant in terms of a new framing (e.g. new regionality, mobile work and opinion formation in the digital age) or that could become environmentally relevant in terms of their presumed future development (e.g. quantum computing and cryptocurrencies). In addition, the topics are presented in terms of their interconnectedness with the ongoing Covid-19 pandemic and, to some extent, the Russian war of aggression against Ukraine. This applies in particular to topics such as mobile work, resilience and world (dis)order. The state of affairs published here is to be understood as a snapshot, because the topics identified are developing dynamically under the influence of the ongoing Covid-19 pandemic and the Russian war of aggression against Ukraine. Against this backdrop, it seems sensible to continuously monitor the future issues.

- **Strategic anchoring within and outside the UBA and BMUV:** The description of the individual topics provides the UBA and BMUV with clues as to where further action and, possibly, further analysis is needed. Depending on the focus of the UBA and BMUV, instruments of strategic foresight can be used for such analyses. The trend analysis method, for example, is suitable for analysing individual trends or future topics from the horizon scanning again separately and in greater depth. Here, all direct and indirect environmental impacts are systematically examined. Trend analyses can also be used to strategically prepare further work on a future topic within and outside the UBA and BMUV. Trend analyses could be applied to the topics of quantum computing, cryptocurrencies and opinion forming in the digital age. Another instrument is the scenario method. It is suitable for those topics where it is currently still very open how they will develop in the future. Normative scenarios, for example, could be used to explore how sustainable city centres might look like in the future. Explorative scenarios could be used to outline the future developments of the topics of mobile work, growing through crises or world (dis)order.

- Ultimately, the issues presented also provide indications that can have a direct effect on the **work in the UBA and BMUV**. The fact that the process could be carried out successfully even under changed conditions, such as the ongoing Covid-19 pandemic and the associated change in the way of working – holding virtual meetings and workshops, predominant mobile work, etc. – is proof of the adaptability of the UBA and BMUV. The results on the topics of mobile work and new regionality can also support the adaptation of the way of working in the UBA and BMUV.

The topics presented in the report are **linked to environmental policy action** in varying degrees. Some of the topics are already the responsibility of the UBA and BMUV and are being dealt with, for example, in the context of research projects. However, some of these are topics that show a need for environmental policy action but are not yet being dealt with in the UBA and BMUV. In the following paragraphs, the key messages of the analysis are summarised for each topic and corresponding recommendations for action are derived for possible further work. Not all open questions that arose during the process could be answered. In the summary below, questions are therefore formulated and can

serve as points of reference for future discussions on the topics mentioned.

- The development of *quantum computers* (see chapter 2.1) is currently still in its infancy. It is becoming apparent that many environmentally relevant effects are not yet foreseeable. So far, questions about the energy and resource requirements that arise during the production and operation of quantum computers have not been answered. However, there are already initiatives, such as the "Quantum Computing Governance" of the World Economic Forum, in which a regulatory framework for the further development of quantum computers is to be developed. Furthermore, not all conceivable fields of application of quantum computing could be presented in the report. In particular, those fields of application whose environmental relevance has not yet been clearly established or that are not compatible with the guiding principle of sustainability were initially excluded from consideration. It therefore makes sense to examine this topic at a later point in time within the framework of a trend analysis. A more in-depth source analysis could then serve to answer the questions that are currently still open from an environmental perspective. The analysis of the positive and negative effects on the environment could also reveal the extent to which there are still data gaps.

- The dynamic and partly volatile developments of *cryptocurrencies* (see chapter 2.2) do not paint a clear picture of whether the trend will continue to develop or grow or whether it will turn out to be a temporary trend. Nevertheless, there is a need for environmental policy. The high energy consumption is already a major problem from an environmental point of view and could become even more problematic in the future. It would be worth examining in how far a CO2 tax on cryptocurrencies would have a steering effect. The aspect of stablecoins could not be evaluated in terms of its environmental impact, because at the time of writing there was still insufficient information, especially on sustainable value anchors and the steering effect in non-sustainable areas. It might be the case that more information will be available at a later date and that this aspect can then be considered again. Due to the dynamic and sometimes volatile market developments and the still insufficient data on the positive and negative effects on the environment, an in-depth analysis would be characterised by a high degree of uncertainty. A trend analysis could nevertheless include an in-depth literature review, the results of which could help to prepare an improved basis for decision-making in the UBA and BMUV.

- The *technical innovations in aviation* (see chapter 2.3) are only one component of a more sustainable aviation that can contribute to the decarbonisation of the transport sector. There is still potential here to support the development of more environmentally friendly solutions, especially in the context of environmental research. However, since the years-long development cycles point to a medium-term perspective in the realisation of sustainable technical solutions, there is also a window of opportunity in the meantime to explore environmental policy options that work towards an overall reduction in air traffic. In the current outline, technical innovations have been considered first and foremost, as they bear great potential for making air traffic more climate-friendly. However, technical innovations are not the only areas of innovation that contribute to making future air traffic climate-friendly; other aspects include optimising flight routes or shifting air traffic to more climate-friendly means of transport. In addition, the holistic consideration of this topic is already firmly established in the UBA and BMUV.

- The *topic of new regionality* (see Chapter 2.4) has received additional impetus from the Covid-19 pandemic, for example through short-term changes in travel behaviour or increased regionalisation of consumption. Russia's ongoing war of aggression against Ukraine is also exerting an influence here, which is particularly noticeable in the energy sector. Although individual developments have great potential to achieve more sustainability, a holistic view and assessment of the environmental effects and the interactions with other developments is recommended.

- *Resilience as a basis for sustainable societies* (see Chapter 2.5) is a complex and multi-layered topic with different connections to environmental and sustainability policy. However, a consistent understanding of the term is necessary to differentiate resilience from similar approaches and to resolve conflicts of objectives. Nonetheless, the concept of resilience is becoming an increasingly important component of environmental governance due to its central importance in Germany's Sustainable Development Strategy.

- In the area of *mobile work, mobile workers and mobile organisations* (see chapter 2.6), the developments of the Covid-19 pandemic have also provided a considerable impetus for change. At present, it is not yet foreseeable to what extent these developments will have a constant character. However, certain options for environmental policy, such as the promotion of efficiency and climate protection measures in data centres and VR, MR and AR technology, or the creation of incentives to avoid business trips and commuting, can be reconsidered or initiated under the assumption of a further increase in mobile work. On the topic of location changes due to *mobile work* (see chapter 2.6), questions have also remained unanswered, for example the question of what kind of living space will be provided and where in order to meet the changing requirements due to new forms of working, or also what social changes – beyond environmental effects – will be caused by a permanently high proportion of mobile work. In addition, the question of the concrete effects of mobile work on the activities in the UBA and BMUV is likely to be of direct relevance to the UBA and BMUV. However, this could not be analysed within the framework of this report and should therefore be the subject of a future research or consultancy project.

- *The European Union's resilience to crises* (see chapter 2.7) is likely to continue to be tested in the future, not only to manage ongoing crises, but also in identifying and managing emerging crises. Appropriate tools such as strategic foresight or resilience dashboards are currently being implemented. While managing crises can reduce the room for manoeuvre in terms of environmental policy, there is also an opportunity, if national and European levels work more closely together and use synergies between different measures, that crises can be used to achieve environmental policy goals. With a view to future potential crises, an explorative scenario development could produce different images of the future that can shed light on how a crisis-proof European Union could react to different types of crises.

- The emerging *new world (dis)order* (see chapter 2.8) puts established international organisations under pressure and should be taken as an opportunity to strengthen them or to establish new organisations that can develop and also implement agile solutions in the fight against the climate crisis. However, the new world disorder can also lead to serious disruptions in the international order. From an environmental policy perspective, support should be given to those people and organisations that are gaining importance in the fight against the climate crisis in the face of these changes. However, many of the political resources are currently tied up in other policy areas, such as domestic, foreign and security policy. The UBA and BMUV could further consider this topic in the form of explorative scenarios, in which different future development paths are drafted and analysed with regard to the various strategic options for action.

- With regard to the topic of *shaping opinions of the future* (see chapter 2.9), it has become clear that the change in the media landscape and the resulting dynamics, especially those influenced by algorithms, can lead to changes in the formation of opinion. Social attention is then diverted from important environmental policy issues such as dealing with the climate crisis. Amplified by multipliers and disinformation, the social consensus for measures to combat climate change can be negatively influenced. This can reduce the scope for environmental policy action. Further analyses can provide additional insights here, for example by conducting an in-depth analysis of the opinion-forming mechanisms and their stakeholders.

- The topic of the *future of city centres* (see Chapter 2.10) is essentially not a new topic for the UBA and BMUV, but it has taken on a new quality due to the developments of the Covid-19 pandemic.

Both pressure to act and windows of opportunity for change have arisen. In addition to the already recognisable potential for shaping environmental policy, however, the topic still has unanswered questions. The UBA project FKZ 3721 11 103 0 ("The Future of Inner Cities – Rethinking Sustainable City Centres with Foresight Methods"), which will start in 2022, addresses this and attempts to formulate answers together with selected municipalities. In the form of scenarios, possible future developments of inner cities will be presented and potential for sustainability looked into.

With the completed horizon scanning process, a compact overview of emerging and environmentally relevant topics is available for the UBA and BMUV. Following this process, it should be a matter of evaluating the available results and translating them into strategic, environmental policy action. On the one hand, this can be done by exchanging views on the individual topics in the form of dialogue formats: workshops, expert discussions or conference contributions. On the other hand, or in addition to the exchange, in-depth analyses may also be necessary to provide additional insights. Whether and how the topics presented here are further developed should be decided on a case-by-case basis. As a result, individual topics may not be pursued further or should be dealt with elsewhere. It is also conceivable that they will be considered again in future horizon scanning processes initiated by the UBA and BMUV, for example if topics or certain aspects reveal new, environmentally relevant qualities.

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