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TOWARDS A BETTER FUTURE

Technological opportunities and threats to the promotion of sustainable development

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Technological opportunities and threats to
the promotion of sustainable development

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Foreword by the Committee for the Future

This report applies the Radical Technology Inquirer (RTI) method developed through the technology foresight projects of the Committee for the Future to assess how technology can help achieve the Sustainable Development Goals agreed in the UN Agenda 2030 Action Plan. Technology foresight is one of the focus areas for the work of the Committee of the Future because technological change has a significant impact on how our future will be shaped. Since the last electoral term, the Committee for the Future has also acted as the reporting committee for the 2030 Agenda report concerning the Government's action plan for sustainable development. The action plan concerns the national implementation of the seventeen 2030 Agenda goals defined by the UN World Summit on Sustainable Development in 2015. That is why it was natural for the Committee for the Future to combine the perspectives of sustainable development and technology foresight during this electoral term. Although technology alone does not make the activities of humanity sustainable, the Committee for the Future deems that it must in any case be used and developed to achieve sustainable development. By commissioning this report from futurologist Risto Linturi, the Committee for the Future has sought to outline what this could mean.

The reader should remember that this report approaches sustainable development specifically through the innovative potential of radical technologies. This approach therefore does not address, for example, how to achieve a more sustainable world by improving and spreading existing technologies, such as by using more efficient engines and stoves or better dry closets. There is already a great deal of information on these opportunities, which must also be used in the pursuit of sustainable development. This report goes further into what the world could be like if the interconnections of the radical technological opportunities that are now emerging were enabled in the most sustainable way possible.

The approach has been developed on the basis of the technology foresight method commissioned by the Committee for the Future. The method has been developed since 2013 (Suomen sata uutta mahdollisuutta: radikaalit teknologiset ratkaisut) and its latest update was published in 2018 (Suomen sata uutta mahdollisuutta 2018 - 2037 – yhteiskunnan toimintamallit uudistava radikaali teknologia). The translation of the update was published in English in 2019 (Societal transformation 2018–2037). The results of the method have also been published as an online application (Tulevaisuuspankki.fi). The established English name of the method is Radical Technology Inquirer (RTI). This year, the RTI method has been applied thematically, both to identify the latest developments in one technology area (Development of genetic engineering in different areas of application 2018–2020) and to examine how technology has contributed to the fight against COVID-19 and how the pandemic has influenced technological developments (Pandemiateknologiat). The present interpretation of the results of technology foresight from the perspective of sustainable development is the latest application of the RTI method.

One of the method's strengths is that the acquisition of the necessary data has been crowdsourced: over 3,000 volunteers, approximately half of whom are continuously active, are looking for news about the latest breakthroughs in various fields of technology and discussing their significance in the social media group curated by Risto Linturi, the main developer of the method. Technological developments will be assessed in relation to how they would provide new means to achieve the objectives established in society as they spread to the markets. These objectives include the movement of persons, nutrition and the maintenance of health. The RTI method therefore seeks to assess through the screening of news of scientific and technological advances and breakthroughs, for example, the extent to which people will be operating passenger transport at the end of the 2030's by using existing mainstream technologies, such as petrol cars, and the extent to which radical technologies, such as robot taxis, will be used. Transitions in the means used to satisfy needs are called technological transformations. The 2018 publication and the Tulevaisuuspankki.fi website describe extensively 20 technological transformations, which are visions of the development estimated to be possible by 2037. The visions have been formulated as credibly as possible in the workshops of stakeholders representing each need. This publication assesses the relationship between these visions and the 2030 Agenda goals.

Let us now sum up the main findings of the report. The list below shows, for each technological transformation, the direction in which the satisfying of needs is expected to shift in the various sectors of society. Technological transformations are organised in such a way that the transformations where the advancement of radical technologies seems to have the widest positive impact regarding the achievement of the Agenda 2030 are listed first. Readers can immediately see that especially learning and knowledge acquisition and energy and food production have the highest comparison figures (indicated in brackets), i.e. the most versatile potential to move towards sustainable development by utilising the potential of new technologies:

- Proficiency and its proof: towards independent learning verified by AI (4.18)
- Energy: towards cheap solar energy and decentralised energy reserves (3.88)
- Acquiring information: towards self-measured and crowdsourced AI data (3.88)
- Sustenance: towards food self-sufficient cities and individual nutrition (3.76)
- Automation of work: towards the robotisation of work and services provided by artificial intelligence (3.18)
- Passenger transport: towards autonomous e-transport as a service (2.94)
- Safety and security: towards individual and crowdsourced safety and security (2.82)
- Remote impact: towards telepresence and virtual meeting places (2.59)
- Existential meaning: towards direct rewards for actions and community work (2.18)
- Manufacturing of goods: towards flexible and individual local production (2.06)
- Exchange: towards distance selling and digitalised transaction platforms (2.06)
- Health: towards a proactive approach to health and gamified self-diagnostics (2.06)
- Materials: towards renewable materials and the circular economy (2.00)

- Collaboration and trust: towards collaboration and international trust platforms (1.94)
- Built environment: towards cities as autonomous housing machines (1.88)
- Power structures: towards impact-based participatory decision-making (1.47)
- Logistics: towards robotised individual transport and loading (1.41)
- Work and income: towards self-sufficiency, sharing and micro-entrepreneurship (1.35)
- Redressing disabilities: towards technical assistance for the disabled (1.35)
- Producing experiences: towards robotised and virtual participatory experiences (1.12)

Based on the report findings, the expected shift in work and income towards self-sufficiency, sharing and micro-entrepreneurship, which is reflected towards the end of the list, is the most controversial in terms of sustainable development. Technologies supporting self-sufficiency help people to make a living, especially in developing regions. However, increasing independence from the financial system, jobs and social safety nets created with tax revenues reduces the direct reasons for self-employed people to be interested in common interests, social regulation and decision-making, and in the environment's power of regeneration outside their own circle of life. This is problematic because globally sustainable development can hardly be achieved without a broad commitment to the necessary decisions and actions, especially as the world population is still expected to grow for several decades. However, as can be seen below, the net impact of the transition towards self-sufficiency, at least in the context of the poverty eradication objective of Agenda 2030, has been assessed to be positive.

Last on the list is value creation related to experiences. Virtual entertainment technologies, which are key to the sector's transformation, have thus been estimated to benefit sustainable development relatively modestly, although digitalisation enables, for example, virtual experiences that involve more physical activity and thus have more health impacts than the current "screen time". However, it is worth noting that the possibilities of supporting sustainable development through virtual community spirit and the rewarding nature of gamification have been estimated to be remarkably high, especially in relation to educational use, but also in terms of meaningful life experience and the maintenance of health.

As can be deduced from the above considerations, certain types of technologies have a particularly high sustainability potential. As part of the work on this report, the following set of radical technologies have emerged, each linked to a particularly wide range of Agenda 2030 goals, thus acting as kinds of building blocks for a more sustainable future:

- Energy reserves and electrification
- Artificial intelligence and digital twins
- Autonomously moving robots
- 3D printing and smart robotics
- Indoor farming and artificial meat

- Solar power and solar fuels
- Green industrial raw materials
- VR & AR and telepresence
- Personal measuring instruments
- Computer-Aided Learning
- Digitalisation of transactions
- Platforms, crowdsourcing and the sharing economy

The report enables the reader to explore the potential that these and numerous other technologies have in terms of sustainable development. Through the links in the report, the reader can also access the broader technology descriptions found on the Tulevaisuuspankki.fi website and can easily proceed from there to the technology news used as the basis for foresight. In this way, it is possible to quickly directly view the technological progress that is currently taking place in the area of interest.

The list below summarises the ways in which technology can support the achievement of the sustainable development goals. All 17 UN Agenda 2030 goals are listed in a descending order starting from the goals having the most numerous and advanced technology solutions related to it. The comparison figures of the goals (in brackets) reflect the diversity of the technological solutions linked to each goal. One should note that although renewable energy technologies are developing rapidly, the comparison figure for the Agenda 2030 goal related to energy availability remains rather low due to the fact that other types of radical technologies do not broadly support this goal. The high comparison figures of the goals at the top of the list indicate that an extremely diverse range of rapidly evolving technologies is linked to the creation of conditions for making a living and a more equitable distribution. Under each of the goals listed below, the report presents selected examples of technology solutions that can support the achievement of the goal in question that are expected to be widely available by 2037.[1]

- End poverty in all its forms everywhere (3.9)
  - Production factors are more evenly distributed when the production and storage of renewable energy, 3D printers and robots capable of customisation enable efficient local production as they develop. Digitalisation of transactions, AI services and platform cooperatives support livelihoods independently of location.
- Promote inclusive and sustainable economic growth, employment and decent work for all (3.9)
  - The conditions for acquiring professional skills will be improved when access to information networks enables telepresence and crowdsourcing, as well as independent training supported by AI. Remote guidance is possible with AR technology in almost any task. Micro-entrepreneurship is facilitated through the increasing use of location-independent production technologies, work carried out on digital platforms and distance selling.

[1] As this report is based on the results of a previous technology foresight exercise for 2037, that is also the reference year in this report instead of the Agenda goal year 2030.

- Ensure inclusive and equitable high-quality education and promote lifelong learning opportunities for all (3.5)
    - Equal opportunities arise when everyone with access to information networks has access to high-quality educational materials and game-based peer learning. Skills are demonstrated, for example, by managing simulated virtual world situations. AI assistants, independent environmental screening with personal measuring devices and crowdsourced data processed with AI are becoming increasingly accessible and affordable.
- Reduce inequality within and among countries (3.4)
    - In particular, cheap energy, such as solar film integrated into building surfaces or synthetic fuels produced locally from water and carbon dioxide, decentralised energy reserves and the development of telepresence technologies, will help bridge global development gaps.
- Make cities inclusive, safe, resilient and sustainable (3.2)
    - Resource consumption and urban mobility can become more sustainable through autonomous and electronic passenger transport, robotised waste management, virtual world rooms in buildings, indoor farming facilities and robotised communal kitchens. Augmented reality and digital twins of buildings will close the competence gap in construction and maintenance. Crowdsourced safety solutions prevent crime.
- Ensure sustainable consumption and production patterns (2.7)
    - For example, carbon-neutral steel and concrete, natural fibre composites and the reuse of carbon dioxide in the manufacture of hydrocarbons and plastics and the life-cycle design of products enable sustainable products.
- Revitalize the global partnership for sustainable development (2.6)
    - The goal requires the availability of skills and information, which is supported by independent learning verified by AI and self-measured, crowdsourced AI data. International cooperation relies on building a good reputation on international trust platforms for distance selling, based on the sharing of peer experiences.
- Build resilient infrastructure, promote sustainable industrialisation and foster innovation (2.3)
    - Reduction in the price of renewable, locally supported energy enables the production of carbon-neutral building materials. Nanomaterials replace much of the minerals. Yeast, fungi and bacterial production can replace many products of the chemical industry. Roof or wall surfaces containing solar panels in new buildings hardly raise construction costs.
- Take urgent action to combat climate change and its impacts (2.2)
    - For example, cheap solar energy and its decentralised storage, electronic transport as a service, urban food self-sufficiency through LED-based indoor farming, cell cultivation and the production of plant-based meat substitutes will enable carbon-neutral urban life and agricultural land to be restored to its natural state. AI-assisted independent learning and crowdsourced AI data, safety and security support climate-wise decision-making and operations.

- Ensure healthy lives and promote well-being for all at all ages (2.1)
    - With the help of people's “digital twins”, self-measured health information can be easily collected and interpreted with AI-assistance, which makes it possible to anticipate the effects of health problems and different lifestyle choices and enables the tailoring of the treatment of diseases.
- Promote just, peaceful and inclusive societies (2.0)
    - AI services and crowdsourcing can be utilised everywhere, but benefits are the greatest where citizens' integrity and legal protection are the weakest. Personal AI-based security programs can be used to identify data breaches, fake information and fake identities. They use crowdsourced information to warn of dangerous situations in transport, people posing a threat, dangerous chemicals, biological risks and counterfeit products. Health threats, seizures and violence may generate a warning and a request for assistance to people in the vicinity or to rescue authorities.
- Achieve gender equality and empower all women and girls (2.0)
    - Robotisation and the proliferation of AI services reduce the importance of physical strength in manual work. Autonomous transport as a service supports the independent mobility of women and girls, and learning verified by AI supports learning that is independent of gender and location.
- End hunger, achieve food security and improved nutrition and promote sustainable agriculture (1.9)
    - Especially the food self-sufficiency of cities made possible by indoor farming supports the availability of fresh and nutritious food. The proliferation of DNA testing and personal devices for the monitoring of vital functions enables individual dietary recommendations. Kitchen robots take into account the appetites, metabolism and allergies of diners. Smartphone sensors (material radars, artificial noses and 3D cameras) detect products and situations and assess their safety. Self-monitoring and the crowd-sourcing of risk information facilitate the decentralisation of food supply.
- Ensure access to affordable, reliable, sustainable and modern energy (1.9)
    - Lower prices of renewable energy production, such as solar panels, wind power, thermal mines and kite energy, as well as the development of battery technology, favour sparsely populated areas that can meet the surface area requirements for local solar energy production better than cities.
- Ensure access to water and sanitation for all (1.4)
    - Indoor farming with closed cycles significantly reduces the need for agricultural water. Affordable measuring devices enable citizens to detect pollutants in domestic and natural waters and submit notifications on them.
- Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss (1.3)

    - The cultivation of fodder plants becomes unnecessary if meat is produced through biotechnology in vats or if food with meat flavour and corresponding nutrient content are produced from indoor plants. This will make it possible to restore agricultural land used for fodder crop to its natural state. Robots can enhance recycling and reforestation and reduce the use of pesticides through physical weeding.
- Conserve and sustainably use the oceans, seas and marine resources (1.1)
    - The transition to renewable energy slows down the acidification of the seas. The increased recycling efficiency associated with the robotisation of work will help reduce the amount of waste in oceans and seas. The shift from the methods of the chemical industry to those used in biotechnology will reduce environmental damage that is dangerous to the humankind and nature. Closed-cycle indoor farming in food self-sufficient cities contributes to the sustainability of seas, oceans and coastal ecosystems.

The Committee for the Future emphasises that despite the exciting potential of many technologies, it is vital to draw attention to the 2030 Agenda goals at the bottom of the list: while technology supports the well-being of humans in many ways, the major challenge is to make the functioning and exploitation of aquatic and terrestrial ecosystems sustainable through technology alone. Radical technologies are of course helpful as they help reduce emissions and increase the efficiency of food production so that the surface area of agricultural land can be reduced. However, technology provides no silver bullet for restoring the balance of ecosystems that is already shaking. In order to stabilise ecosystems rapidly, it is therefore absolutely necessary to make other kinds of political decisions and introduce restrictions to ensure he regenerative capacity of nature.

The second message from the Committee is that, although technological progress is not expected to stop, it will not in itself progress in a way that will inevitably support sustainable development. Individual technologies do not change the world but must be interlinked and linked to the work and everyday life of people in a way that creates new ways of doing things. The technological changes described in chapter 2 of the report are such systemic descriptions of how human needs can be met through new approaches. The chapter also assesses the impact that each change has on sustainable development. These impact assessments have been marked by Risto Linturi, the author of the report, with “key Agenda 2030 impacts” subtitles.

When reviewing technological changes, one can see that in theory they allow for much more sustainable practices than modern technology. But what exactly must happen in order for theory to turn into practice? The paragraphs relevant to this question are titled “preconditions for change”. Each change has its own preconditions, that is, assumptions on what it takes for the vision to become reality. The preconditions are related in particular to the performance and price that technologies must achieve before they can compete with current solutions. However, the standardisation of technology interfaces, investments in specific public infrastructures, the dismantling of regulations and standards that favour old structures and, in some cases, even the dissolution of privacy in order to achieve other equally valuable objectives are also recognised as preconditions for favourable technological development. These are issues that policymakers can address if they consider the technological changes described in the report to be desirable ways to support sustainable development.

The above-mentioned preconditions are necessary for each change but they alone are not sufficient. Related to this, Linturi has also sought to identify in advance the causes and developments that could lead to unsustainable and even criminal ways of using technology or that could produce unintended side effects, which would increase harm to the natural environment or human health, or lead to the accumulation of capital, resources, opportunities or freedoms in the hands of the few. Linturi has labelled these potential downsides of the development as "key tensions". While the inspiring effects of Agenda 2030 are seen as the front of the technology coin, the main tensions and the ethical prioritisation they bring up are the inevitable reverse side, which also needs to be explored in order to achieve sustainable development. Confronting and alleviating tensions by reforming legislation and policies is at the heart of decision-makers' work. This report draws a map on the tensions that can be reviewed in order to take a different approach than just reacting to problems when they become apparent. Anticipation and preparedness turn problems into challenges and guide development past threats and towards opportunities.

The "Towards a Better Future" report is also a new kind of research opening when it comes to assessing the sustainability impacts of technology. It assesses the development potential of technologies as part of society through the lens of socio-economic ecology. Technologies are often assessed more narrowly, such as through life-cycle or carbon footprint analyses. Or sustainability is considered at the organisational level in corporate responsibility and sustainability reports, where sustainability is based, for example, on how much emissions are generated or how workers' rights are respected. The difference between these approaches and the RTI method is that in traditional methods, evaluations are proportional to the present rather than to what a sought-after, better future represented by the report's visions of technological transformation would be. Knowledge of the features of existing solutions and their refinement is naturally needed. However, gradual improvements can also lead to a deadlock, such as the pursuit of carbon neutrality only by saving energy. Decision-makers and innovators also need tools to assess what alternatives to a gradual continuation of the current trends could be available and what the necessary sustainable approaches could be. The RTI-based method addresses this need.

But how can something as complex as the sustainability impact of technology on society as a whole be assessed? This requires two things. Firstly, technologies are not assessed in isolation but, in this report, they are bundled together into the above-mentioned visions of systemic technological transformations. Secondly, because sustainability is a value-based concept, it is necessary to make the underlying assumptions of the assessment visible. For each sustainable development goal, Linturi presents a set of questions with which the impact of technological transformations was assessed. For example, the 2030 Agenda objective of "ensure healthy lives and promote well-being for all at all ages" (UN SDG 3) has been converted into the following technological indicators used in the analysis: "Does the technological transformation facilitate access to general health information or will it contribute to the effectiveness of health information? Does it help expand diagnostic capabilities or access to medicines for populations currently excluded from health services? Does the technological transformation make treatment methods for serious illnesses more effective in a widely accessible way? Does it reduce mental problems caused by exclusion or other causes? Does it reduce the risk of accidents or communicable diseases? Does the technological transformation reduce environmental damage that is dangerous to humans? Does it promote healthy lifestyles, for example, in terms of nutrition and physical activity?"

These sets of questions are, in fact, an exceptional innovation. The Committee for the Future is not aware of other equally systematic attempts to operationalise the link between technologies and sustainable development at the level of society as a whole. With the publication of this report, anyone can transparently assess the coverage of the question sets, which also enables the model to be freely utilised and improved.

At the beginning of chapter 3, Linturi sheds light on the thinking through which the key features of the 17 UN goals with extremely varying nature have been modelled in order to enable technology impact assessment. The "bottlenecks and economies of scale" in the centre of the diagram, as well as the "potential differences" presented alongside them, are the core concepts of the model. Society is understood as a system the specific characteristics of which create potential disparities regarding, for example, resources, opportunities, energy and health, that is, unequal distribution. The sustainability of development, on the other hand, has been interpreted from two angles: On one hand, it is the reduction of potential disparities, which means more equal access to valuable things. On the other hand, it is the reduction of externalities caused by indifference and ignorance, which is supported, for example, by the transparency of operations and information.

For example, more equal access to knowledge contributes to sustainable development. In the past, access to high-quality teaching and educational materials has been a bottleneck, which is disappearing due to technological development. AI-based translation lowers language barriers and digitalisation and the sharing economy make high-quality learning materials available to all motivated learners with online access. This will reduce competence gaps between regions and people. In addition, digital learning materials, artificial intelligence and cheap measuring devices allow knowledge to develop faster on the latest issues than if information was distributed only in traditional ways, first to all teachers and then through them to pupils. This type of narrowing of disparities has the greatest significance in the developing regions, the importance of which may be challenging to perceive from Finland, where potential disparities are small. Therefore, it is the technologies of knowledge and know-how that offer enormous opportunities for Finland to be profiled as a sustainable development expert in international fields. However, technological and marketing expertise alone are not enough for this. Existing learning technologies are still clumsy and the associated technological transformation is just beginning. However, the forerunner in the world of learning technology will be the one who combines technology expertise, gaming competence and the best pedagogical understanding of the means of distance learning.

The publication is primarily intended to be read in the digital format: the report text contains numerous links, which can be clicked so that the electronic version of the report opens background publications and further information on the technologies used as examples.

The Committee for the Future would like to thank Risto Linturi for his tremendous work for providing information on the link between sustainable development and technology in this report. It is encouraging that technologies can justifiably be linked to positive developments in the global well-being of humans. They can and must be used to reduce the pressure of human activity on nature, while using non-technological means to find a balance between ecological sustainability and the size of humankind. Let us be positive and forward-looking – we have many opportunities to create a sustainable future.

Helsinki, 4 November 2020,

Committee for the Future

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1. Introduction

This report presents a comprehensive technology-driven global improvement programme and assesses it against the UN Sustainable Development Criteria. The 20 visions described in the report renew all networks of organised value creation in society and form a compatible whole. It shows how the combined effect of radical technologies emerging in different sectors can change the world. In previous work, the same visions have been presented and shown to be both possible and credible from a forward-looking perspective. This report summarises them in a more readable format and assesses the impact of their implementation from the perspective of the sustainable development goals.

There is a broad consensus on the importance of technological development for sustainable development. However, no previous systematic impact analyses on the operational visions have covered all aspects of society, as far as is known. The potential benefits of individual technologies have nevertheless been widely assessed. (WIPO 30 August 2020, World Economic Forum 24 September 2019, UNCTAD 6 May 2019, Institute for Transformative Technologies 2019, IISD 27 September 2019, PWC 17 January 2020, WSJ/Deloitte 23 September 2019)

The UN's action plan for sustainable development, Agenda 2030, is an ambitious, legally binding document that has been widely approved by states. The main content of the action plan consists of 17 goals, which are further divided into 169 targets. The Finnish Parliament's Committee for the Future is responsible for monitoring the related national action plan. In connection with this task, the Committee for the Future has decided to investigate in more detail the role of technology and the related opportunities, especially in relation to the promotion of sustainable development.

The Committee for the Future has exercised systematic technology foresight, which has resulted in the publication of seven reports on radical technologies. The most recent of these is the comprehensive foresight report, Societal transformation 2018–2037. 100 anticipated radical technologies, 20 regimes, case Finland (Linturi&Kuusi 2018). It analyses and describes the transformation made possible by radical technologies in all sectors of society. The time horizon for the visions is 10 years until early operational realisation and 20 years until broad societal impact.

This report presents the first version of the method for anticipating the impact of technological transformations on sustainable development and on the 2030 Agenda goals. The impact of individual technologies is not assessed here, as that depends on how they are used. It is more justified to assess the potential systemic combined effect of technologies. In this report, 20 new approaches that are credibly enabled by technological transformation have been selected for evaluation. They are first formulated as systemic visions. The actual assessment is based on targets and general causal assumptions concerning, for example, the impact of production factors, power structures and knowledge on the indicators of inequalities, productivity and externalities that are presented as targets.

The method is tested in two steps: First, the 20 transformations identified in the Societal transformation 2018–2037 report are summed up as concise visions. After this, the expected impact of each vision on the 2030 Agenda goals over the time horizon of the visions is assessed.

The viewpoint is global and has a long time horizon. Radical technologies rarely mature in one decade to the extent of having a wide impact. However, the approaches have been chosen in such a way that efforts to achieve the benefits of sustainable development can begin immediately. The transformations can take place during the 2030s.

Chapter 2 describes the visions of technological transformation. Instead of focusing on technologies, the focus is on the new societal approaches enabled by the development, that is, on socio-technical systems. The vision also presents the technological assumptions regarding the transformations, the impacts of the vision on the 2030 Agenda goals and the main tensions related to the transformation.

Chapter 3 first presents the rationale for the evaluation method and then the key indicators used in the method for each Agenda 2030 objective. At the same time, the technological transformation visions with the greatest impact on the achievement the goals are presented separately for each goal.

Chapter 4 reviews both the method and the results as a whole. The method works, but it can be refined in many ways. Each of the technological transformation visions presented is assessed to have a positive overall effect.

The visions are deliberately written as worthy of achieving, as bold but possible structures, as steps and means towards a better world. The visions are not problem-free – their realisation involves risks and sacrifices. The visions are neither deterministic predictions nor can they be realised without effort. The tensions that were identified and even unidentified tensions can prevent a vision from becoming reality and turn the benefits of technology into disadvantages. Therefore, visions are possible futures until they become reality. The world can change for the better, and the envisioned role of radical technologies will be a major one in tackling global challenges if that is what we want together.

The author thanks the committee for the assignment, which develops the foresight method and is important in terms of content, as well as Olli Hietanen, Counsel to the Committee, and the committee's permanent expert Maria Höyssä for important advice and encouragement. I would also like to thank Osmo Kuusi, who participated in the development of the original versions of the visions, and the dozens of experts of the national innovation system who commented on the visions during the draft phase of the Societal transformation 2018–2037 work. I would also like to extend my warmest thanks to the hundreds of members in the Radical Innovations crowd-sourcing group of the Committee for the Future, with this report being based on information collected by them. Special thanks to the following people who have commented on the drafts of this report: Arto Aalto, Kari Alanne, Kate Alhola, Timo Ali-Vehmas, Nea Barman, Juha Ekberg, Veikko Hintsanen, Grändi Hytönen, Mika Järvenpää, Kari Kaakko, Jari Kaivo-oja, Arno Karatmaa, Pekka Ketola, Antti Kiikka, Antti Kolari,

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2. Technology transformations by value creation network

Technological development makes it possible to create value through new means. The Societal transformation 2018–2037 report, as well as the active follow-up work since then, have gathered and evaluated through crowdsourcing over 2,000 scientific and technological news about the development of radical technologies. The potential significance of the observations has been analysed by dividing the organised activities of society into 20 different value creation networks based on their primary objective. For each value creation network, an alternative to the current approach has been developed, which the new technology seems to allow. In defining the approach, the interests, values and standards of the various stakeholders were taken into account along with, for example, new professions and risks and contradictions related to the policy. The alternative approaches are titled as follows:

Passenger transport: towards autonomous electronic passenger transport as a service
Logistics: towards robotised individual transport and loading
Manufacturing of goods: towards flexible and individual local production
Sustenance: towards food self-sufficient cities and individual nutrition
Energy: towards cheap solar energy and decentralised energy reserves
Materials: towards renewable materials and the circular economy
Built environment: towards cities as autonomous housing machines
Exchange: towards distance selling and digitalised transaction platforms
Remote impact: towards telepresence and virtual meeting places
Automation of work: towards the robotisation of work and services provided by artificial intelligence
Work and income: towards self-sufficiency, sharing and micro-entrepreneurship
Health: towards a proactive approach to health and gamified self-diagnostics
Redressing disabilities: towards technical assistance for the disabled
Acquiring information: towards self-measured and crowdsourced AI data
Proficiency and its proof: towards independent learning ensured by AI
Producing experiences: towards robotised and virtual participatory experiences
Safety and security: towards individual and crowdsourced safety and security
Collaboration and trust: towards voluntary work and international trust platforms
Existential meaning: towards direct rewards for actions and community work
Power structures: towards impact-based participatory decision-making

This chapter describes these new approaches as crystallised visions. They will not happen automatically. These are potential objectives, the achievement of which requires not only technological progress but also action by society, for example, at the level of competence development, investments and legislation. Technologies themselves allow for a wide range of approaches from which various parties and society together shape the socio-technical mainstreams they want. The visions chosen for this are deliberately positive and assume that societies are capable of largely cooperative activities. However, we are not talking about utopias. The visions are believed to be entirely achievable.

The descriptions are optimistic. Alternatives where people cause a technological catastrophe, such as nuclear war, are not explored. Many new technologies enable such dystopian alternatives. Although unfortunate futures are not described, the intention nevertheless is that the assumptions regarding the realisation of the visions and the counterforces of development are mentioned. Attention is also drawn to the disadvantages and risks arising from the visions.

The future is in the hands of humans. The objectives are very diverse and there can be surprises in technological development. Therefore, the threats, opportunities and juxtapositions described in this report offer at best only a partial view.

Each vision is described at a global level and the estimated target states are illustrated by examples. The benefits of the visions in terms of the 2030 Agenda goals are described in separate paragraphs. The technological and technology policy levels required to realise the vision is presented after this. The perceived drawbacks of the vision and the tensions that prevent realisation are described in a separate paragraph. The method for assessing the benefits and disadvantages is described in chapter 3. Observations are summarised in chapter 4.

2.1 Passenger transport – towards autonomous electronic passenger transport as a service

Current state: People have a constant need to travel from one place to another. Passenger cars with drivers, light personal transport vehicles and public transport have formed the mainstream of value creation. The recent technological transformation has already made digitally rented city bikes and electric scooters common.

The envisioned technological transformation is robotised electronic service traffic. Robot cars pick up persons in need of transportation from a place or stop of their choice and automatically go to the next person in need when released. Changing the mode of transport is easy as there is no need to search for a parking space or to pick up or return a car. Small shuttles are used in sparsely populated areas, mass transit is used on trunk routes, light transport and covered walking routes are used in city centres and elsewhere if deemed appropriate. Urban tunnels and electronic robotised aerial taxis solve some of the congestion problems for travellers with the tightest schedules.

In service use, the utilisation rate of means of transport will multiply and, for example, the total number of passenger cars will be drastically reduced by the mechanisms of the sharing economy. The need for parking areas will collapse, freeing up urban space close to residential areas, jobs and services. The electrification of cars lengthens the service life of cars and reduces both maintenance and operating costs. In addition, both mass transit and passenger car transport will become cheaper in terms of production costs as the driver costs disappear and the use of equipment becomes more efficient.

Prerequisites for the transformation: The vision assumes that battery technology will improve so that the production and recycling of batteries do not cause significant damage to the environment. It is also assumed that the price of batteries will fall and the batteries will last a million kilometres, so that the share of batteries in the cost per kilometre of a passenger car will fall to less than one cent per kilometre of driving. Artificial intelligence is expected to develop so that vehicles can cope with standard routes in their area of operation, and if a vehicle is in a strange situation, remote control from the service centre can guide the vehicle forward. Artificial intelligence is therefore not required to survive independently in all places and conditions, but it is assumed that, for example, one remote controller per 100 cars is enough. Further information on battery development, robot cars and aerial taxis is available in the Tulevaisuuspankki.fi -later referred to as Future Bank.

Agenda 2030 impacts: Technological transformation offers multiple means for poverty eradication. Freedom of movement can be achieved by means of an autonomous service at a lower cost and without vehicle ownership. The transformation contributes to health by reducing the risks of infection and accidents, as well as the adverse environmental impacts on humans. The transformation advances the situation of women by disregarding the need for a driving licence and the ownership of a car, which in some societies are mainly reserved for men. The electrification of transport will disconnect it from its dependence on oil and it will increase energy efficiency. At the same time, locally produced solar energy will have additional storage capacity. Facilitating personal mobility brings significant and comprehensive added value, which contributes to sustainable economic growth. The transformation helps reduce inequality by reducing the variable and fixed costs of mobility and the use of limited resources. The transformation improves cities and residential areas by broadening employment opportunities, by increasing the safety of transport and by reducing the environmental load on cities. Tourism, consumption and production requiring passenger transport will become less environmentally damaging. From the point of view of international climate action, systemic changes in mobility create a motive for cooperation that accelerates global development. Passenger transport provided as a service develops most efficiently with the help of global AI. This will lead to extensive cooperation. From a legal perspective, autonomous systems prevent a large part of the typical threat of violence and provide reliable evidence in criminal cases for crime-solving and for determining liability.

Key tensions: Autonomous transport will not be able to respond to all situations without human assistance. In order for it to function reliably, it will require, at least in the 2030s, a service centre that supports the various means of transport. There is a risk that oligopolistic structures will emerge in services. It is also possible that the provision of autonomous transport services to economically weaker or sparsely populated regions will be limited. The establishment of services is also technically demanding and relies on technologies developed by a few companies. The market price of services therefore depends on the competitive situation and business models, but also on government regulation and participation in the development. Given the concentration of intangible rights, it is not entirely incontrovertible that the transformation would reduce the productivity gap between developed and developing countries, even if this was the case otherwise. The most likely business models for robotic traffic are commercial and controlled by their operators, so it is unlikely that the impact of urban residents or the urban environment on this urban traffic planning will materialise widely by other means than through zoning and customer relationships.

2.2 Logistics – towards robotised individual transport and loading

Current state: The transfer of physical products in the production chain from a manufacturer to a user or from one user to another is a global need. The most significant mainstreams of logistics value creation are currently the transfer of large homogeneous batches of raw materials in the production chain and the transfer of finished products from the manufacturer through distributors to retail outlets from which customers collect them. Recently, e-commerce has rapidly increased the share of individual mail and courier deliveries in the supply chain.

The envisioned technological transformation is robotised and individual transport of goods to the user from the producer or party holding it. According to the vision, intelligent robots load and unload goods individually into heterogeneous transport or storage spaces. Autonomous lorries, delivery lorries, water and air drones, light transport vehicles and people crowdsourced through the platform economy move goods between sorting stations and directly to their users or, for example, to city block-specific lockers. The documentation for the goods, a kind of digital twin, can be found online using the individual product identifier. The product performs its freight handling by using its digital twin and, for example, assigns the keys to the lockers or the transport documents to each operator of a multimodal transport route.

Robotic operations reduce the need for large wholesale consignments and intermediate stocks. Products are transported from artisans to consumers almost as cheaply as bulk products are currently transported from large factories to giant markets. Digital twins improve security, anonymity and flexibility as documents are digitally protected, each part of the transport chain knows only the next delivery point, and progress can be tracked and the final address changed during transport. Retail trade based on the collection of goods becomes largely unnecessary. Digital twins also facilitate shared use of consumer durables, the sharing economy and recycling.

Prerequisites for the transformation: The vision will be realised in stages. Many loading and sorting steps have already been robotised. Wider automation requires robots that recognise the characteristics of goods and their suitability for loading and robots that are suitable for autonomous transportation, with prototypes of such robots being already widely tested. Robots do not have to cope autonomously in all situations if an operator controls them remotely in demanding situations. Decentralised distribution requires that lockers are available to delivery robots near households. As transport activities are fragmented between different operators and through crowdsourcing, this requires the standardisation of unique product identifiers and the related documents so that they are digital twins accessible to the holders of rights. In the Future Bank (Tulevaisuuspankki.fi): light transport vehicles, drones and the Internet of Things.

Agenda 2030 impacts: The envisioned logistics transformation increases well-being and improves its distribution, as it reduces the transport costs of special goods creating individual added value. At the same time, the vision will increase equal opportunities for small and medium-sized production operators and it will improve access to an affordable distribution channel, as well as access to goods in sparsely populated areas. The increased efficiency of individual logistics will enhance the competitiveness of farms and direct sales in the vicinity of population centres in relation to food wholesalers' distribution channels.

Robotised logistics enables the delivery of diagnostic healthcare tools for telemedicine needs, as well as individual deliveries of medicines to areas with poor availability of healthcare. Robotised logistics promotes the equality of women, as it reduces dependence on both passenger cars used to pick up goods and physical strength. The productivity of production workers increases as the distribution of custom-made goods and other specialty goods becomes easier. Innovativeness will increase when access to an efficient logistics channel is not controlled by large wholesale operators or dependent on large delivery volumes.

The key global operators in e-commerce have extremely wide product ranges and, through this, a clear motive to promote robotised individual deliveries. If realised in accordance with the vision as an open logistics channel, this will also bring efficient logistics to developing countries, open up efficient supply channels for products from developing countries and reduce productivity disparities and the dependence of value creation on major commercial operators. Opportunities for cooperation between cities and their surrounding areas will also improve as logistics favours smaller operators and consignments. Recycling becomes more efficient through individual identification and sorting of goods and through the robotisation of transport.

Key tensions: The vision does not fully satisfy the needs of those for whom shopping is a social experience. The vision may also lead to unemployment by reducing the extent to which logistics is dependent on human resources and by replacing it with capital-intensive robotisation. If automated logistics structures emerge as closed systems for large traders, the benefits related to the decentralisation of production jobs may not be achieved. By increasing individual and heterogeneous freight transport, the vision also easily increases the consumption of packaging materials. Anonymised and crowdsourced robotised deliveries also enable the transport of dangerous explosives and chemicals for criminal purposes. In addition, autonomously moving logistics robots can easily be harnessed for terrorist purposes unless they are monitored with sufficient care.

2.3 Manufacturing of goods – towards flexible and individual local production

Current state: Our way of life is filled with things. Whether it is accessories, appliances or furniture, they are mainly now produced in series in a centralised manner in large automated factories. From there, an extensive distribution chain delivers them to users. Mass customisation has been developed and many production lines are capable of some degree of flexibility, but the mainstream of value creation is centralised and standardised industrial production.

The envisioned technological transformation is flexible local production where local production lines in the service areas produce individually a large part of goods and their parts for each area. An example is an intelligent robot that has hands and makes customised products in the same way as a skilled artisan. Another example is 3D printing. A 3D printer in the back of a store produces, for example, spectacle frames, lamp shades or tool handles according to the user's physiology and preferences. The added value of individuality is obvious. Most of the envisioned production and service work is local. Local materials can be favoured in material selection. Networks supported by platform cooperatives are created to combine local capabilities. Storage and logistics costs and waste will be reduced. A competitive channel for local planning and culture is opened up next to the channels of large production plants. In the vision, much of the digital models needed to make goods and components are available either at a very low cost or free of charge through open crowdsourcing.

Not everything is produced locally. Complex components, such as digital memory or processor circuits, will still be produced centrally. The production of products or parts of products benefiting from individuality, cultural links or low delivery costs and their assembly, including finishing works, will be carried out locally. The individual part of customer needs analysis and consideration will also take place locally. In the vision, a significant part of production may become part of locally or globally chained services, for example, in the form of production platform cooperatives.

Prerequisites for the transformation: The competitiveness of local production compared to global mass production is technologically linked to the flexibility of production tools, that is, how short and versatile series can be produced efficiently. Production costs may exceed the cost of mass production, provided that the individual nature, local origin or logistics cost generate sufficient added value. 3D printers are developing rapidly and are already reaching the envisioned level in some respects, especially in products made of plastic and composite materials. Free and inexpensive model libraries are also increasingly available and can be openly co-developed. The same applies to hybrid products with interfaces where a core component is serially produced, but the individual component can be printed. Robots that match the human dexterity of an artisan are still a way off, but progress is rapid. In the Future Bank: 3D printers, robots with hands and robotic tailor.

Agenda 2030 impacts: An increase in flexible local production capacity will reduce dependence on international trade, which is easily disrupted particularly in crisis situations. An increase in diversified local production will increase inclusiveness and equal opportunities while reducing the risk of exclusion and mental problems. Local flexible production is mainly versatile and wide-ranging work that does not rely on narrow theoretical knowledge and it is suitable for a wider group of people than theoretically-oriented highly automated industrial work. The transformation promotes self-learning, teaching and demonstration of competence, as the goods and equipment designed through learning can be easily manufactured. This also makes teaching and learning more attractive. Economic growth will be boosted by making it easier for designers and small businesses to access the markets with new products and individual added value. Value creation will no longer be so dependent on structures managed by large industrial players, such as narrow engineering expertise or production and distribution systems. This reduces inequalities both between regions and within regions. Local innovation expertise in developing countries will develop and opportunities for participation in production activities and planning will increase.

Key tensions: Flexible production facilitates criminal activities. The production of counterfeit products and controlled products such as weapons will be easier. Infringement of intellectual property rights will be easier and the monitoring of organised activities may become more difficult. With local production, tax evasion may also become easier. The chaining of flexible production into global systems where local parts of the network print 3D models managed by the chain may steer the benefits of value creation in a more centralised direction. Technology itself provides clear interfaces and such concentration can be prevented by appropriate regulations.

2.4 Sustenance – towards food self-sufficient cities and individual nutrition

Current state: Food production is mainly based on industrial-scale cultivation and livestock farming, where the resulting food raw material is seasonally stored, industrially processed and centrally distributed. Distribution to consumers is carried out by retailers, institutional and workplace canteens, outdoor markets and restaurants. Meat imitation products and urban cultivation are gradually competing with traditional production.

The envisioned technological transformation is local production of food raw materials as a daily local process, as well as the individual preparation of food from fresh raw materials in robotic kitchens or by manpower. Plants will be grown as hydroponic layers and, where appropriate, by using LED lights. This only requires 1–5% of the area needed for field cropping, so cultivation can take place in urban tunnels, basements and rooftops or balconies. In the vision, the cultivation of fodder plants becomes unnecessary, as meat is produced through biotechnology in vats or food with the flavour and nutrient content of meat is produced from indoor plants. In the case of local and continuous food production, storage, preservation and transport are needed only in exceptional cases. Kitchen robots prepare meals for each eater while considering personal preferences, metabolism and allergies.

The vision drastically reduces the need for agricultural land, even if part of the arable area is used for solar energy production. The food industry's use of chemicals and food waste will decrease. Fresh, unprocessed food is more nutritious than food produced by the food industry or stored as seasonal crops. Nutrition adapted to metabolism and preferences has clear added value. In indoor farming, GMO products do not pose a risk to nature and environmental damage and plant or animal diseases do not spread.

Prerequisites for the transformation: Solar and wind energy and the efficiency of plant lights must be improved and costs further reduced in order for the vision to be broadly realised. Solar energy production must be sufficient and based on thin films with low environmental impact. Varieties suitable for layer cultivation must be developed for different product groups. The vision assumes that the production of food crops as a continuous process requires 70–90% and protein production 90–95% less agricultural land relative to production volumes. These figures include the area required for energy production. The figures assume an energy efficiency ratio of 10% for cultivated food crops when lighting occurs at optimal rhythm. Light is produced so that it is accurately directed at plant surfaces and only at the required wavelength. Robot kitchens are expected to become more common first in restaurants and institutional catering, starting from countries with high wage costs. Whether the envisioned process is more or less capital-intensive and higher in variable costs than the current one depends on the cost of soil, technology and labour, but competitiveness will improve over time. In the Future Bank: genetically modified plants, artificial meat, indoor farming and robot hands.

Agenda 2030 impacts: The vision has no direct impact on poverty, but it removes the link between food production and arable land. In particular, the vision facilitates access to affordable protein-rich food and reduces its production costs. Restrictions on food production and damage to the environment will be reduced. In crisis situations, the problem of dependence on food produced in other regions or centrally managed food resources will be reduced.

The end of cattle farming reduces the risk of infectious diseases spreading from animals to humans and individually prepared fresh food provides better conditions for a healthy life. With indoor farming and biotechnological meat production requiring only a fraction of the volume of water used in arable and livestock farming and as farming takes place on a closed loop, all kinds of agricultural damage to the environment will be reduced. The majority of agricultural land can be restored to its natural state. These factors have a significant impact in terms of reducing CO_2 emissions, restoring natural ecosystems and reducing chemicalisation.

Continuous small-scale food production speeds up the study of food production, as teaching and experimentation do not have to follow the rhythm of natural harvests. A freer rhythm makes studying more attractive and it also increases opportunities for innovation. Compared to farms with increasing size and the centralised food industry, as well as the largely automated distribution system, the vision of local urban farming with individual robot kitchens can be considerably labour-intensive. Decentralised local production is likely to reduce productivity disparities, both between regions and between countries. Climate change complicates agriculture, but production taking place in line with the vision can also work effectively in changing climate conditions.

Key tensions: Indoor farming increases the energy requirements of food production and renewable energy, which is becoming increasingly cheaper and rapidly increasing in volume, is a prerequisite for the success of the vision. A unified electricity market may hamper the conditions for indoor farming. Transforming the food culture towards the vision may be challenging. The use of existing protein sources involves a considerable number of links to values, knowledge, habits, standards and agreements. Restoring agricultural land to its natural state affects the value of agricultural land and creates tensions. In the vision, large numbers of workers will be freed from farm work, food trade and restaurant and institutional catering, and they would need to be directed towards new duties. It should be noted here that agriculture, the food industry and trade are also constantly increasing their automation and competitiveness.

2.5 Energy – towards cheap solar energy and decentralised energy reserves

Current state: Global energy production is mainly based on burning coal, natural gas and oil. In 2019, the worldwide share of carbon-neutral forms of production was only 15%, of which hydroelectric power is the largest. The share of energy reserves in the balance between production and consumption is small, except for stocks of energy raw materials. The response to fluctuations in demand is to adjust production. The share of solar and wind power is growing rapidly and this increases the need for energy reserves. A significant part of energy production is concentrated and based on a massive distribution infrastructure, in terms of energy raw materials, processing and electricity and heat production.

The envisioned technological transformation is based on the replacement of fossil energy and on a significant increase in distributed carbon-free energy production and storage. Flexible and efficient solar films that are being developed will in the future be integrated into all surface structures during the manufacturing phase. Most built surfaces will be harnessed for solar energy production. Kite energy reduces wind power costs and increases applications. In large areas, locally produced and stored renewable energy will be cheaper than fossil energy and other centrally produced and distributed energy. Synthetic fuels are manufactured efficiently and cheaply from water and carbon dioxide with the help of catalysts. The processes can be started quickly, not much capital is needed and therefore cheap solar and wind overcapacity at peak times is used as an energy source.

In the northern regions, thermal energy storages are becoming more widespread as long-term energy reserves alongside synthetic fuels. In energy consumption, the share of electricity and especially locally produced electricity is increasing, which is reflected, for example, in the electrification of transport. The average production cost of reliably supplied electricity in the northern areas reduces at a slower rate than the cost in regions having more favourable conditions for solar energy throughout the year. The electrification of processes and the decentralisation of energy production reduce the importance of economies of scale in industrial production. The development favours sparsely populated areas that can meet the surface area requirements for local solar energy production better than cities. As access to energy is no longer dependent on centralised distribution infrastructures, the cost of modernisation in underdeveloped sparsely populated areas will fall.

Prerequisites for the transformation: Solar and wind energy and energy storage technologies must become more efficient and cheaper in order for the vision to become reality. In the vision, the efficiency of film-like solar cells is expected to increase to the level of 30–40%, with costs decreasing so that roof or wall surfaces containing solar panels in new buildings hardly increase the construction costs. The capital cost of small-scale synthetic fuel production must fall to a fraction of the value of annual production in order for the vision to be realised in northern latitudes having practically no sunlight in winter. The price of fuel cells and microturbines that produce heat and electricity efficiently from synthetic fuels is expected to fall drastically. The price of batteries is expected to halve every 10 years, while capacity doubles and life expectancy multiplies, but batteries are not expected to be suitable for long-term energy storage in the vision. In the Future Bank: the development of solar energy, thermal energy storages, synthetic fuels, electricity storages and batteries and fuel cells.

Agenda 2030 impacts: The vision reduces poverty by providing an affordable way to generate energy. At the same time, dependence on centralised energy infrastructure and fossil fuels will be reduced. The vision does not require biofuels that compete for the cultivated area for food crops. Most of the variable costs associated with energy production and consumption, as well as the disadvantages of fossil energy and bioenergy, will be eliminated. Local production's independence from structures increases resilience and the equality of opportunities, as well as the ability to cope with changing climate conditions. The vision drastically reduces the CO2 emissions of energy production, but increases the need for recycling electronic waste. On the other hand, the need for power distribution and district heating networks will reduce when access to reliable and sustainable energy will be easier.

Affordable electricity produced at fixed costs facilitates, for example, the production of clean water in salt water areas. In addition to clean water, excess electricity from peak production can be used to also produce other raw materials and materials that are easy to store. The use of electricity instead of fuels typically increases the efficiency of processes. Local efficient electricity generation enables cheap electricity supply in areas with underdeveloped infrastructure. Activities in line with the vision are more decentralised and labour-intensive than the current mainstream. The competence requirements for the installation, deployment and maintenance of decentralised systems are low and bring added value to wide markets, so technology clearly contributes to economic growth and employment. Easy local access to electricity contributes to the sustainable development of other production in a way that reduces inequality locally and globally. At the same time, the electrification of peripheral areas will provide the population of such areas with access to digitalisation.

Key tensions: Activities in line with the vision increase the capital requirements for residential heating in sparsely populated areas when compared to heating by burning energy raw materials. As a means of helping the poorest regions, this corresponds to the building of wells that requires help from wealthier people.

Reduction of environmental damage depends on how harmless materials are used to build the equipment needed in the vision and how recycling of energy waste is organised. The fall in energy prices will not be visible to consumers if cheap production does not meet demand and the market price is determined by the most expensive form of production. Tensions also stem from the cost allocation concerning the electricity transmission network, as many users disconnect themselves from the grid and as there are disputes between interest groups due to the deterioration of the conditions for business that depends on fossil energy.

2.6 Materials – towards renewable materials and the circular economy

Current state: Globally, the primary source of raw materials used in the production of goods is the extractive industry and, secondly, the bioeconomy. Both minerals and biotechnological raw materials are most commonly processed by energy-intensive processes using chemicals on a large scale. These cause extensive environmental damage. Actions have been taken to reduce the use of raw materials through recycling. In the field of materials technology, processes are constantly being developed in a biotechnological and sustainable direction, and efforts are being made to produce minerals by means that are more environmentally friendly.

In the technological transformation vision, materials are produced and recycled in sustainable ways. Construction concrete has been replaced with carbon-neutral substitutes, such as so-called green concrete, bio-technical bricks that harden in sunlight and strong natural fibre-based composites. Carbon dioxide has been introduced as an industrial raw material for the production of hydrocarbons, plastics and nanocarbons, among others. Steel is produced in a carbon neutral manner by using solar energy and hydrogen. Nanomaterials developed from renewable raw materials will replace the majority of mineral products. Raw materials and materials produced by yeasts, fungi and bacteria at room temperature replace many of the products of the chemical industry.

Together with artificial intelligence, the labelling of products, components and packaging, as well as sensors that detect materials, enable efficient robotic recycling and the use of recycled materials as raw materials. There is increasing determination to develop materials that are either biodegradable or easily recyclable. The development of the circular economy creates industrial-commercial symbioses in which the entire life cycle of products is planned.

Prerequisites for the transformation: Carbon capture technologies and reactive catalysts are expected to develop in such a way that the production of hydrocarbons and nanocarbon through renewable energy is cost-effective. Together with the energy consumption of the mining industry, concrete and steel production currently generates the majority of material-related CO_2 emissions. Steel processing with methods based on renewable energy and hydrogen is already progressing at the level of industrial investment decisions. The replacement of cement with carbon-binding materials is progressing through experiments by development laboratories and the methods are expected to mature for widespread use. Biotechnological processes and nanomaterials are expected to develop sufficiently in terms of their properties to replace a significant part of mineral products and energy-intensive or environmentally harmful processes and materials. Recycling is expected to become substantially more efficient than today and integrate to form a systemic circular economy. In the Future Bank: green concrete, green steel, CO2 as raw material, new strong and light materials, nanomaterials as fibres, biotechnology manufacturing and the circular economy.

Agenda 2030 impacts: The impact of the vision on poverty is contradictory. Dependence on minerals will decrease, but new materials may not be cheaper than the previous ones. However, as materials that are based on biotechnology replace minerals and processes become less energy-intensive, it is reasonable to assume that variable costs will decrease. In any case, the replacement of large industries by smaller-scale processes increases the equality of opportunities.

The decline of the mining industry and the development of the process industry towards renewable energy will reduce the use of fossil fuels. The shift from the methods of the chemical industry to those used in biotechnology will significantly reduce environmental damage that is dangerous to the humankind and nature. This will contribute to access to clean water, health and the sustainability of aquatic ecosystems. The vision has a major and clearly positive impact on the sustainability of consumption and production patterns, regarding both the sustainability of raw materials and harmful emissions.

The vision has a positive effect on economic growth through the renewal and decentralisation of production. The shift from limited resources to renewable raw materials also contributes to economic growth. Recycling and biotechnology rely on local materials and labour to a greater extent than traditional industries. In addition, they are more labour-intensive and, when decentralised, less unequal than industries that are based on mineral products.

Key tensions: Both steel and concrete are inexpensive materials that are well suited to their intended purpose, and there are well-established methods for their production and use. Replacing them with more ecologically sustainable materials requires significant social incentives. Traditional material technology investments are long-lasting and should be amortised if abandoned. The decisions also have an impact on employment. Processes using renewable raw materials require separate investments, which may be larger than investments in traditional technologies when comparing production. At the same time, the decentralisation of processes and the use of local raw materials compensate for the costs of substitute products. Many processes using renewable materials and recycled materials are technically demanding and may not be easy to implement in the least developed regions. New methods may also entail a large number of intangible rights. It is possible that the vision, at least initially, will not help reduce inequalities between regions, even if it will reduce intra-regional disparities.

2.7 Built environment – towards cities as autonomous housing machines

Current state: The majority of construction and the maintenance of the built environment is still human resource-intensive, even though a lot of mechanical power is used. Apart from streets and roads, the environment is built for humans to walk in. Urban structures are largely organised into separate work and service areas and residential areas.

The built environment is regenerating at a slow pace. However, the way in which premises are used is constantly changing towards the new needs and opportunities of an increasingly digital society.

The envisioned technological transformation is an infrastructure that favours autonomous transport of passengers and goods, in which construction and maintenance are largely robotised. The replacement of privately owned passenger cars with shared robotic transport vehicles frees up a lot of urban space. The space requirements of shopping centres are also reduced thanks to online shopping. Due to remote work and remote service use, the purpose of homes is expanding and the space requirement for housing is increasing, while the need for office space is decreasing. An increasing part of built surfaces generates solar energy, which is stored and used locally.

Robotisation of construction, maintenance and distribution requires that the built environment becomes easy for robots to navigate. Standardised lockers where goods can be left are built in the vicinity of apartments. In the vision, waste management and indoor and outdoor cleaning are robotised. Augmented reality and digital twins of buildings will close the competence gap in construction and maintenance. Construction defects decrease as development progresses in both human and robotic tasks. The robotisation of construction is progressing gradually from mold-free casting to robotic masonry and coating, but also to the manufacture of factory-made room elements. Virtual world rooms and indoor farming rooms, as well as communal robot kitchens in residential buildings, are examples of new elements introduced by the vision. Factory-made off-grid housing modules for sparsely populated areas will become increasingly common, and they include autonomous energy, water, food production and bio-waste systems.

Prerequisites for the transformation: Autonomously moving robots will not function without an extensive, public charging system. The vision expects robotics to evolve through artificial intelligence and remote control so that robots and people can use the same routes for transport. The manipulation of tools and other goods must also succeed at the same level as when performed by a professional human being in order for the vision to become reality. Remote work and remote services are expected to increase with the individual distribution of goods, robotic kitchens and shared virtual worlds. In the Future Bank: robot cars in passenger and freight transport, sensitive robotic fingers and hands, 3D printing of buildings and structures, robotised services, fresh water production, LED cultivation, off-grid housing.

Agenda 2030 impacts: Improving the functionality of cities and buildings improves the ratio of capital and added value creation as it also reduces variable costs. Crisis resilience increases as a result of the decentralised structure of operations. Improved logistics reduces especially the cost of food distribution. The favouring of remote work and automation reduces the commuting costs, infectious diseases and accidents. The robotisation of maintenance and construction reduces the importance of physical strength and largely by-passes work duties dominated by men. Increased energy self-sufficiency of buildings reduces the concentration of energy production, the disadvantages of energy production and its dependence on fossil energy sources, and contributes to the availability of energy in areas with weak infrastructure. The electrification and automation of operations improve energy efficiency.

Developments in line with the vision contribute to economic growth by reducing the use of bottleneck resources and externalities and by generating significant new added value for customers in large markets. In addition to sustainable infrastructure, innovativeness improves as decentralisation and operational smoothness increase. Intelligent distributed robotics makes it easy to add and adapt new functionalities. The vision reduces inequalities through the mass-production nature of robotisation. Robots naturally have the same skills. After product development, multiplication adds only a small variable cost, so it is worthwhile to seek the widest possible market for products and services. This development is expected to increase the efficiency of high-quality housing production and maintenance, while reducing the cost differences between high-quality and low-quality housing.

Robotised maintenance, efficient logistics and increased energy self-sufficiency reduce the externalities caused by cities. They also promote sustainable production and consumption patterns and safe urban structures. Robotised operations facilitate regulation and promote opportunities for crime reduction, knowledge exchange, statistics and action against climate change.

Key tensions: Developed countries would be able to adopt the vision faster than developing countries, but the rate of new construction is fastest in developing countries. The vision replaces many construction, logistics and maintenance tasks mainly with autonomous robots. Productivity growth depends on the creation of sufficient added value and skills to replace these jobs. Cities as housing machines can also cause harm by reducing the physical activity of people in their everyday life. One problem may be the extensive dependence of visionary activities on intangible rights and the primary impact that global commercially developed software has on automation practices.

2.8 Exchange – towards distance selling and digitalised transaction platforms

Current state: The mainstream of global retail continues to be based on shops and sales where the buyer picks up the goods. The transfer of ownership takes place at checkout; products are selected based on marketing messages and people's own observations. Exhibitions, personal negotiations, complex bilateral subcontracting networks and long-term subcontracting agreements play a key role in business-to-business trade. E-commerce is rapidly changing retail, wholesale and subcontracting.

In the envisioned technological transformation, e-commerce and platform business expand so that they become mainstream. Marketing messages are increasingly replaced by verified peer reviews. Personal experiments are replaced by digital twins having the dimensions and preferences of the consumer and with VR/AR presentation material for e-commerce products adapted based on them. Transactions are digital. Consumers' purchases are transported to the customers' lockers or home and packaging materials are recycled. Physical shops are mainly focused on individual consulting and service, where, for example, measurements are taken, accessories created or spare parts manufactured.

Trading between companies has largely been transferred to be conducted through platform companies. Platform companies standardise interfaces, demonstrations and quality control. They also deal with logistics, payment transactions and contracts. Platforms also guarantee and standardise even contractual situations in which a subcontractor manufactures the products according to the customer's specifications and intangible rights. The procedure will simplify contract practices and the finding of reliable partners, while also increasing the flexibility of subcontracting. Instead of the courts of states, the primary resolver of violations of contractual obligations will be the platform operator and its quality controllers.

A growing share of exchange shifts to outside the monetary economy as the sharing economy becomes more widespread. In business-to-business activities, the free sharing of resources is becoming more common, especially for intangible resources. In addition, by means of crowdsourcing, intangible resources are produced on shared platforms for everyone to use. The sharing economy provided by platforms also facilitates the sharing of resources between consumers.

Prerequisites for the transformation: In order for the vision to become a widespread reality, the logistic infrastructure must develop so that it supports robotised home deliveries. This may require regulatory action. In business-to-business trade, the development of digitalisation, standardisation and independent testing services contributes to the realisation of the vision. Platform operators can rely on their own logistics system or general systems. The effective use of general logistics requires the standardisation of the unique identification of goods and the digital twins jointly used by all parties. In the Future Bank: robotisation of distribution, e-commerce, commercial platforms, community platforms, digital twins of goods.

Agenda 2030 impacts: The vision reduces trade costs and facilitates access to goods especially in remote areas. With lower transaction costs and more open access to an efficient distribution channel, small and remote operators have better possibilities to earn money. Free access to jointly developed intangible materials and the sharing economy increase the equality of opportunities and reduce dependence on centralised structures. This can be expected to reduce poverty and facilitate the widespread dissemination of expertise. Open co-development has a particularly strong impact on the availability of educational materials. The platform economy contributes to equality by creating a gender-neutral interface between trading parties.

The vision contributes to economic growth by improving comparability. Reduced transaction costs and having fewer logistic bottlenecks will also increase the added value created by exchange. The increase in added customer value is evident, for example, in the expansion of the product range, the rapid market entry of new products and the globalisation of trade. Added value will increase in a decentralised and labour-intensive direction if the management of logistics structures is not used to support closed business ecosystems. The vision is likely to reduce inequalities both within and between countries, as it opens transaction interfaces and reduces all transaction costs. Platforms reduce the possibilities of corruption and greatly facilitate the handling of contract breaches. The vision facilitates international cooperation.

Key tensions: Traditional distribution channels have managed their own networks from purchasing and logistics to retail outlets. City planners have supported the approach. Regarding e-commerce giants, Amazon aims to have its own logistics structures. So far, there is no effective open distribution logistics and the parcel delivery of postal operators and couriers does not appear to be flexible enough for cooperation without regulatory action. Continued centralisation and the closed nature of distribution is therefore a clear risk, despite the technological potential. The significant role of platform operators as nodes of economic activity leads to a situation where the power of individual state actors is reduced and the approach chosen by platform operators becomes similar to laws and regulations, with the platform operator acting as a judge. This extends to the distribution of physical products a practice familiar from Facebook, whereby Facebook determines, in accordance with American standards, which images each person can share with their friends. If the position of the operator is strong enough, breaking the standards of the platform means breaking customer relations and communication.

2.9 Remote impact – towards telepresence and virtual meeting places

Current state: Until recently, remote impact has mainly taken place through mass media, telephones and electronic messages. Video conferencing is rapidly becoming more common and an increasing number of devices is remotely adjustable or remotely controllable. The proliferation of remote work and remote services during the mobility restrictions caused by the Covid-19 pandemic has accelerated the adoption of new practices.

The envisioned technological transformation makes interactive remote encounters an integral part of the mainstream of remote impact. Video conferencing will be replaced by encounters in shared virtual worlds as well as virtual and physical avatars. Virtual avatars are characters projected into the physical environment of a viewer using AR glasses, with gestures and expressions corresponding to the movements of the conversation partners. Physical avatars are robots whose face and gestures can reflect the movements of its controller. A physical avatar can also be a remotely controlled drone, snow plough or harvester. The avatar controller sees the remote environment or a model of it and is able to measure things in a remote environment or handle them using the means available to the robot.

Shared virtual worlds are similar to gaming worlds, but in addition to games, they are also intended to be used for meetings, planning, educational situations or intangible services. A virtual space can correspond to an actual physical space or it can be completely imagined. Visitors can see the space and each other's characters projected into a virtual room or through VR glasses. Virtual world objects can be handled and this may also affect events in the real-world environment corresponding to the virtual environment. For example, virtual laboratory tests can be robotised and repeated in a physical laboratory.

The vision of remote impact also includes artificial intelligence. Some of the avatars and characters encountered in a shared virtual space are guided by artificial intelligence in the same way as is the case with some of the current social media communicators and robots responsible for business services. Under the guidance of artificial intelligence, the means of individual communication can be harnessed for mass communication. Artificial intelligence can, for example, act as a participant in discussions or a provider of remote services.

Prerequisites for the transformation: In order for this vision to be realised, high-speed and low-latency data communications connections, such as 5G networks, must be widely available. VR and AR glasses must develop into light glasses or sunglasses with a resolution equivalent to that of the eye. Virtualisation and animation techniques must become automated and ordinary. The autonomous moving of avatar robots in public spaces must be made possible. A reasonable price level must be reached for convenient walking robots that have hands. In the Future Bank: Global Wireless Broadband, VR-glasses, AR-glasses.

Agenda 2030 impacts: In the envisioned operations, dependence on time and place is reduced. Work can be carried out regardless of the location, in which case, for example, the availability of affordable housing in the working area does not become a restriction and there is no need to lease office premises. The costs of facilities and travel are eliminated. Equal opportunities will increase substantially, while risks will decrease.

Knowledge transfer will be greatly facilitated by telepresence. Distance learning in shared virtual reality feels natural, but classrooms and observation tools are virtualised. Remote guidance with AR technology is easy in almost any task. Artificial intelligence can take care of part of the teaching; a virtual environment with the possibilities of practising makes learning attractive and game-like. Equality increases as dependence on location decreases; women and girls have more freedom of choice and the exercise of regional power becomes more difficult.

The growth in the productivity of labour is evident as travel time is eliminated and know-how becomes readily available everywhere. Virtualisation increases the possibilities of added customer value. Large markets are accessible from anywhere and almost without resource constraints. Avatar robots help connect the virtual world to the physical world. Avatars can be controlled from any location. Global communications will be standardised, AI will help remove the language barriers of global virtual reality and the cost of meeting a wide range of needs will fall, especially when technology matures.

Key tensions: The vision can reduce physical movement and alienate people from their local communities. In addition to positive remote impact, the envisioned actions open up a lot of opportunities for destructive operations. An example of current remote impact is the military use of drone technology. The proliferation of remote-controlled devices may make it easy to use them so that they are made to operate in ways that are harmful or dangerous to humans. An example of a different kind of a problem related to labour legislation is cross-border service work, which can replace even local physical work by means of avatars. When there is high labour supply, competition for work may lead to a collapse in wage levels. In many situations, the transition of work and services to virtual reality hinders the administration of justice and control of criminal activities.

2.10 Automation of work – towards the robotisation of work and services provided by artificial intelligence

Current state: The majority of labour productivity is based on help from machinery and equipment. Machines have been used to replace physical strength and automate repetitive or dangerous work phases. Technical devices have also been used to transfer, modify and archive messages and replace senses. Machinery has increasingly been developed to automate work even in situations that have previously been thought to require human consideration. Machine translation and robotic vacuum cleaners are examples of already common practices.

In the envisioned technological transformation, autonomous robots and AI services take on a large number of tasks that only humans have been able to perform. Examples include the transport of vehicles, the design and manufacture of individual goods, health monitoring and expert-type identification and classification of observations.

The cost of many tasks, when carried out by artificial intelligence and robots, may decrease even radically. For example, translation service is provided free of charge as a part of the services offered by social media operators. When translating between major languages, the quality of machine translations is on average similar to a rough professional translation. The cost of work carried out by physical robots may also be significantly lower than the cost of human work. The decrease in labour costs is reflected in the prices of competing services and in operating methods. For example, in weed control, we can abandon herbicides and go back to weeding.

The vision leads to a world where robot and AI services are extremely affordable everywhere and routinely used. Goods are manufactured to individual dimensions and transported home. Robots clean, transport garbage and prepare food in an individual manner. Artificial intelligence tells stories and creates virtual worlds, acts as a digital guardian angel, tutor and family doctor. People discuss with each other what robots should do next and how to solve problems. Although robots read emotions, in the vision they still lack an understanding of human meanings and the general intelligence that many call common sense.

Prerequisites for the transformation: The vision will inevitably be realised, at least in part. The extent of the realisation of the vision depends, in particular, on the proliferation of cheap service robotics and the establishment of clear separation of the related software and hardware interfaces. The speed and extent of implementation depend not only on the development of artificial intelligence and robots imitating human abilities, but also on the development of regulation and the standardisation of robotics interfaces. Privacy protection may slow down the growth of service robotics especially in Europe. Standardisation or the establishment of de facto interfaces is a prerequisite for a rapid price decrease for capabilities and for the growth of the mass market for service robots. The vision does not require the emergence of strong artificial intelligence, but only the integration of the principles and capabilities that already exist in research laboratories into commercial industrial products. In the Future Bank: speech technology, conversational and emotional robots, artificial intelligence in expert tasks, robot ecosystem interfaces, global artificial intelligence work, robotised services, robot cars.

Agenda 2030 impacts: Poverty is reduced by replacing massive industrial automation with decentralised robotics that can be harnessed for production independent of location. The dependence of production on local know-how is reduced as AI acts as an advisor or the performer of knowledge-intensive activities. In food production, artificial intelligence and the help of robots help grow crops and reduce the use of herbicides and fertilisers. Robots also help effectively with recycling, identifying and eliminating environmental damage and spreading environmental awareness.

Storage and personnel costs for logistics and trade will be reduced and understanding of healthy food will increase. AI and robotics help remove language barriers and provide learners with inexpensive educational materials and high quality teaching, regardless of location. The impact on women's equality is positive, as robots reduce the importance of physical strength and digital systems mainly treat men and women in an equal manner. Robots can also prevent violence and exploitation.

The vision promotes economic growth through the development of knowledge and by increasing productivity. Growth is also created through price flexibility as a wide range of new value-adding methods and services become profitable. Growth can take place in a way that is not hindered by resource constraints or knowledge bottlenecks. Growth combines activities into global competence networks where, like global companies, Wikipedia or the scientific community, competence is accumulated through cooperation and widely distributed.

Key tensions: Robotisation and AI development largely replace current work tasks. It is unclear how quickly and to what extent the opportunities that open up will create new jobs. These developments are likely to lead to exclusion and mental problems. Robotic services can easily form closed hierarchically managed value chains, in which the majority is left with the role of a customer or subordinate franchisee. The ability of local operators to influence the activities carried out in their area may be limited. In the worst-case scenario, robotisation enables citizens to be subjected to widespread oppression, despotic administration and automated terrorism.

2.11 Work and income – towards self-sufficiency, sharing and micro-entrepreneurship

Current state: Today, income is mainly based on specialisation and exchange. The majority of work is carried out within organisational hierarchies. Work is rewarded with money to buy goods and services produced by other people within the framework of their organisations. In undeveloped economies, work carried out for oneself is referred to as the subsistence economy, while in industrialised countries it is referred to as domestic work or self-service. Over the past decades, the volume of self-service, added value created jointly through voluntary work and non-monetary exchange has increased in industrialised countries.

The envisioned technological transformation is based on the increasing ease of co-development and crowdsourcing, artificial intelligence and robotisation. Wikipedia, Youtube and various smartphone applications for special fields have shown how easy it is to accumulate and share common knowledge. Artificial intelligence and teaching material that is available everywhere reduce competence gaps. As for flexible robotics, it diminishes the importance of the economies of scale. This is likely to reduce the need for specialisation and exchange.

The decrease in specialisation and exchange implies a decrease in monetary economy and paid employment. Instead of buying something, we make it ourselves. Many will produce their own energy in the future. Technically, it is also becoming increasingly easier to produce food, medicines, clothing and goods yourself or to produce them using the collaborative tools of the sharing economy. With artificial intelligence and the developing measurement technology, we are able to produce expert assessments for ourselves, whether it is about health, nutrition or the quality of work performance. And when AI is unable to give advice, crowdsourcing can help.

The platform economy offers the opportunity to earn money as a micro-entrepreneur. The work may be random and fragmented, rewarded with reputation and money according to success. However, in the envisioned world, money will no longer be needed to the extent that was previously necessary because people create a large proportion of value for themselves and outside the monetary economy.

Prerequisites for the transformation: The vision requires the development of artificial intelligence and robotics and is gradually becoming reality. In addition to technology, the development of self-service close to the level of self-sufficiency requires the dissolution of regulation regarding the way that it now artificially supports hierarchical operating models. This means, for example, intangible monopolies, bureaucratic structures for community action and competence requirements maintaining personal specialisation. In the Future Bank: personal analysers, artificial intelligence experts, 3D printing, 3D printing of biomaterials, platforms for voluntary work.

Agenda 2030 impacts: The vision reduces the dependence of wealth on the financial economy and enables better satisfaction of needs for those who do not benefit from the productivity benefits of specialisation and exchange. The vision reduces personal productivity disparities and dependence on controlled resources. Being able to produce things that meet your own needs and the needs of your loved ones increases the meaningfulness of life and reduces exclusion and resulting mental problems. The vision decentralises production, expands its flexibility and thus increases resilience. As the satisfaction of needs depends directly on one's own skills, the motivation and rewards of learning increase.

Modern self-sufficiency requires that decentralised renewable energy becomes widely common and leads to energy-efficient practices. Talking about economic growth is problematic as the importance of money diminishes, but the vision can contribute to the growth of well-being by reducing transaction costs and by increasing in all actions the share of added value related to the satisfaction of direct needs. The crowdsourcing of intangible design know-how and the easy availability of decentralised robotic tools through the sharing economy will increase productivity, especially in poorly industrialised regions. Partial detachment of productivity differences from centralised industrial hierarchies and past competence systems seems obvious. This facilitates the acquisition and use of local skills and other local resources. The increase in civil liberties also seems obvious in relation to the vision.

Key tensions: The potential decline in the financial economy reduces the possibilities of income transfers by government finances. Therefore, the realisation of the vision may impair the livelihood of people who are unable to be self-sufficient in the current welfare states. The growing local economy also increases opportunities for exploitation and violence and undermines the position of women. Isolated, local activities increase cultural differences. The reduction in physical exchange slows down the global harmonisation of equal laws and practices, despite the vision of global exchange of know-how. The weakening role of states and globalisation could also jeopardise the regulatory and financial actions for fighting climate change. The expansion of the subsistence economy is likely to increase the area under cultivation and other land use, as well as cause other externalities that are difficult to control.

2.12 Health – towards a proactive approach to health and game-based self-diagnostics

Current state: Medical action is now taken when a person is injured or feels ill. If necessary, one seeks health care services. The cause of the problem is determined by laboratory tests and a doctor's diagnostic methods. Guidelines related to lifestyle and medical care are based on demographic models, such as the Current Care guidelines and nutrition recommendations. DNA testing and the increasingly widespread use of devices monitoring vital functions by citizens are gradually shifting attention to individual foresight.

The vision of the technology transformation is based on people's digital twins and continuous monitoring of vital functions. A digital twin is a computer model that extends from human cells to organs, and it is based on an individual's genotype and implemented as accurately as possible in each case. The model is calibrated using health wristbands or other personal sensors and research data from laboratories and doctors. It helps anticipate problems, provides alerts when anomalies are detected and guides you to lead a healthy life through gamified means. For example, the model can show the body's condition in the future if the current or alternative lifestyles are continued. The digital twin may also indicate in advance how tissues react to the proposed medication.

With the help of the digital twin, personal measuring devices and artificial intelligence, symptoms and other potential problems are identified early on and will not become serious before measures are taken. Concerns about health are reduced when one can rely on continuous monitoring. The individualisation of lifestyle guidelines and medication leads to better treatment outcomes than Current Care guidelines and demographic lifestyle recommendations. A significant proportion of medicines can be assigned by AI and the digital twin under the supervision of pharmacies.

Continuous expansion of medical knowledge, digitalisation and detailed cellular biology modelling lead to the ability to detect various cancers or infectious diseases at very low concentrations and even in wastewater. Those who have fallen ill can often be identified on the basis of results. Developments in cell biology also seem to lead to ways of slowing down ageing and prolonging healthy life even by decades.

Prerequisites for the transformation: Laboratory techniques and self-diagnostic tools are rapidly developing. The realisation of the vision is based on the assumption that the price of biochips will be cheap. Methods of robotics and photonics turn consumer devices into small laboratories, and using them for self-diagnostic tests does not require special laboratory expertise. This vision will be gradually realised and does not require comprehensive operation of digital twins at the molecular level. In addition to the technical prerequisites, the nature of medicine as a highly regulated activity must be taken into account. In order for this vision to become reality, it is necessary to change regulation so that it favours self-diagnosis in the largest markets for healthcare equipment. In the Future Bank: DNA readers, cell metabolism, cellular biological model, self-diagnostic devices, biochips, extending human lifespan.

Agenda 2030 impacts: Health problems are a major cause of poverty, but they are also part of the consequences of poverty. Compared to traditional health care, the vision offers very affordable ways to improve access to health information and individual diagnostics in both developed and developing countries. Individual and accurate information in a gamified predictive format increases the effectiveness of both health information and lifestyle-related information. Cheap measuring devices and services provided by AI are easily accessible even in areas where access to medical care is difficult.

The vision contributes to economic growth by improving the health of the population and by increasing the added value of health information so that it is predictive and favours individual, healthy lifestyles. At the same time, the accumulation of medical research data will be significantly facilitated. Self-diagnostic tools and AI play a key role in reducing inequalities. There will never be a sufficient number of the best experts to care for every person, but the best AI is the one with the widest experience. Healthcare assisted by the best artificial intelligence and self-diagnostic equipment can therefore be widely available. The vision helps achieve a good level of public health without expensive hospitals and rare top experts.

The vision promotes peaceful societies by making a promise of long-term health. At the same time, the envisioned practices help uncover abuse and make it easier for citizens to access information that affects their own health.

Key tensions: Continuous monitoring of vital functions and the transfer of data for comparison by AI may jeopardise privacy. In particular, genetic and lifestyle data can, in the wrong hands, expose people to risks. Vision-based lifestyle measurement can lead to the medicalisation of life. The use of data collected by self-diagnostic tools in health care decisions raises the question of liability limits and is not appropriate for the current practices, where healthcare operators are responsible for the information used for diagnosis. More responsibilities must be allocated to the manufacturers and users of devices so that health care can operate in line with the vision. A radical increase in healthy life could make power structures more rigid and increase inequalities. On a large scale, it would also significantly burden the living environment.

2.13 Redressing disabilities – towards technical assistance for the disabled

Current state: People whose capacity differs from that of healthy adults are usually assisted by other people. Children and the elderly, as well as the intellectually disabled, are cared for in institutions or assisted at home. Persons with reduced mobility are assisted in terms of transport and the moving of their personal items. Medical assistance may be provided in relation to vital functions and, for example, simple devices may be used to compensate for visual or hearing impairments. The development of technical aids and prostheses has accelerated. Many scientific prostheses already remind us of cyborgs in science fiction films.

In the envisioned technological transformation, the autonomic ability to function of physically or intellectually disabled people will be supported by increasingly technical instruments. This may include, for example, various functional prostheses, artificial organs, crowdsourced platforms for remote counselling or digital guardian angels. The aim of development is to reduce dependence on institutions and restore people's autonomous functional freedoms to normal levels. Crowdsourcing helps develop artificial intelligence and solve problem situations that exceed its capabilities.

Machine vision helps visually impaired people describes objects, gestures and expressions in the field of vision. Speech recognition turns speech into signs for hearing-impaired people. A digital guardian angel warns of the dangers on passageways or related to situations and guides how to operate safely or alerts help if necessary. Crowdsourcing advises in situations that AI cannot manage. Foot and leg prostheses or wearable walking aids help people with reduced mobility to get up on their feet from their wheelchairs. Wearable exoskeletons and hand braces help one carry things. Artificial pancreases, artificial kidneys, myocardial enhancers or neural pacemakers are individual examples of functional assistance related to internal organs.

Aids designed to provide functional assistance can also improve a person's ability to function beyond normal levels. An anti-tremor spoon in the hands of a Parkinson's patient can also help others. Goods transporters, muscle enhancers, perception enhancers and visceral enhancers can increase people's performance beyond natural levels.

Prerequisites for the transformation: As far as technical assistance is concerned, development is more dependent on the decisions of organisations that help people with disabilities than on technological progress. Even cheap methods may remain unused if they are not required by the standards. People who depend on the help of others often have no choice but to adapt to the old methods if that is what the structures of the organisations that provide care for them guide them to do. The realisation of this vision does not essentially require fundamental technological progress, but awakening to new opportunities and a desire to support a more independent life for people with disabilities. Practices are expected to shift in the direction of technological assistance. This contributes to the spreading and continuous improvement of methods and to a decrease in their price. In the Future Bank, robot legs, cyborgs, artificial organs, environmental recognition, speech recognition, recognition of emotions.

Agenda 2030 impacts: The vision helps reduce poverty and the related disadvantages, as it substantially reduces the need for care facilities and effectively increases the chances of independent coping. The importance of maintaining or improving independent living and working capacity as a means of eradicating poverty is surely obvious. Although the vision does not actually cure diseases or injuries, it helps mitigate or eliminate the impediments caused by them in widely accessible ways. At the same time, action in line with the vision clearly reduces many health risks. In addition to the risk of accidents, the risk of exclusion and mental problems, violence and exploitation will be reduced as independent capacity for action is restored. Lifelong learning opportunities will also increase. Gender equality will be enhanced not only by greater independence from physical strength, but also by the possibility of assistance through digital guardian angels and crowdsourcing.

The vision promotes employment as it increases work capacity and supports independent mobility. Freeing society's resources from institutional care also contributes to economic growth. As a reducer of inequalities, the vision provides an opportunity for independent living and well-being for those who lack it because of their physical disability. If the vision is realised, the burden on many health care services will decrease and resources can be directed to other value-adding services.

Key tensions: The development of functional aids has not resulted in a dynamic structure similar to that of pharmaceutical development covering patients who are able to function, insurance companies, doctors and the pharmaceutical industry, which constantly requires the adoption of the best treatment methods. The financers deem permanent injuries as facts that are already reality, the costs of which are not seen to be reduced by means of assistive devices. Under current regulations, it is true that technological restoration of the ability to function would not, in practice, reduce the costs for insurance companies or society. Disabled people have also often become passive and rely on institutional care. Traditional methods are offered as aids, but the actual development responsibility is borne by only a few active parties, such as the Federation of the Visually Impaired in Finland. When society functions in an sub-optimal manner, the tools and related practices develop slowly and on the terms of those who are most privileged.

2.14 Acquiring information – towards self-measured and crowdsourced AI data

Current state: Most people obtain most of the information they use by reading and listening to reports, news or textbooks. Although information at the level of society is generated through observations and experiments, the majority of all the information we have is based on other people's interpretations and what they tell us. Digitalisation has recently slightly reduced the importance of intermediaries and increased the share of peer information. Through the internet, we can directly access an increasing number of measuring devices and original sources of information. Personal measuring instruments are also becoming more diverse.

In the envisioned technological transformation, information will be obtained more directly. People use mobile cameras and a wide range of other smartphone-related measuring devices when they search for information. Artificial intelligence helps identify characters, materials and situations through these observations. Even sophisticated measuring devices, such as DNA readers and material radars, will become common. For example, it is not necessary to read in the product description what substances some specific food or textile contains, or to consult the Regional State Administrative Agency's data to find out how clean the water in the area is. It can be determined by measuring the object optically or by using a biochip. Machine vision interprets the expressions of fellow human beings, the toxicity of fungi or the names of birds and flowers. Biotechnological analysis may even tell us where the food comes from or what chemical compounds are present in our neighbour's breath.

Crowdsourced observations accumulate in common databases, where AI generates summaries of them or draws causal conclusions. Everyone can obtain almost direct observations of any locations they want, their previous condition and forecasts of future conditions. Combined with expert knowledge and models, this leads to applications that you can use to obtain information and advice for your individual needs. Therefore, new information is local and combined according to individual interest. Artificial intelligence, for example, automatically adds new research publications to it. Despite the fact that much of the information currently provided by humans is unintentionally or intentionally misleading, the misleading effect of individual sources can be revealed. In the envisioned future, this will be done through crowdsourcing and artificial intelligence by using trust structures. The sources of information are identified and those who share measurement data deviating from others are ignored. Low-quality services will not become widely used as they provide users with no benefits.

Prerequisites for the transformation: The vision will be realised gradually. It requires the development of measuring devices and the accumulation of machine vision learning materials in connection with widespread use. The vision also requires that the origin of data is reliably identified and that unreliable data is eliminated in the crowdsourcing process. It is expected that a large part of the measurement data will be generated through people's own terminal equipment, but direct observation data will also be generated from robotic traffic, satellites, drones monitoring the environment or other autonomously mobile devices and industrial processes. In the Future Bank: facial recognition, AI expert applications, material scanner, DNA reading, crowdsourcing for data collection, peer trust.

Agenda 2030 impacts: Direct and crowdsourced data collection facilitates access to relevant and situation-oriented information. This will increase equal opportunities by reducing dependence on centralised and limited data acquisition channels. The crowdsourcing of health information, healthy lifestyle, good farming practices and numerous other types of information, as well as the comparison of individual direct observations, improve nutrition and promote health. The vision of learning opportunities opens up a completely new and inspiring perspective, as gaining experience through everyday tasks through personal measurement data, guidance from artificial intelligence and benchmarking becomes the main way to develop skills.

Measurement and crowdsourcing help reduce and detect pollution in water and soil, while avoiding their adverse effects. Improved direct access to information on production and needs creates significant added value for customers, innovations and savings related to factors of production. The widespread use of research data will accelerate and the least developed countries' access to information on matters concerning them will be facilitated to a particularly great extent through the means of direct observation. The vision can be clearly seen to reduce inequalities both within and between regions.

Direct observations, AI and crowdsourcing increase the safety of mobility, reduce the threat of all forms of violence and crime, increase the transparency of organisations and ecosystems, climate action, consumption and the downsides of tourism, improve the functioning of the justice system and increase opportunities for participation. Immediate, crowdsourced observations interpreted by artificial intelligence and free from deliberate distortion, support the implementation of sustainable development at all levels.

Key tensions: It is difficult to see any disadvantages in the vision, assuming that crowdsourced data is based on actual observations and not misinterpreted by AI. However, there are many obstacles to the realisation of the vision. Many power structures seek to harness the dissemination of information to their advantage. Some people are ideologically grouped in such a way that the truth is not even of interest, but group-specific observations and opinions are much more important for success within a group. The proven ability of social media to corroborate inaccurate information may lead to significant counterforce to the envisioned developments. On the other hand, reality is always present in such a way that relying on false information and observations at the practical level produces poor results. Therefore, direct observations and their reliable crowdsourcing provide a positive reward for users, which makes it difficult to go against the vision, at least in situations involving personal actions.

2.15 Proficiency and its proof – towards independent learning verified by AI

Current state: Mainly, we learn many of our basic skills from textbooks, as taught by our teachers at school and by our parents at home. We learn specialised skills in educational institutions, courses and workplaces. Learning and identifying skills or skills shortages are mainly teacher-led. Educational materials, lectures and demonstrations of various skills are increasingly being produced for free online use, where and when necessary. Qualifications are awarded separately through educational institutions, but micro-qualifications that are independent of teaching and based on demonstration of competence are gradually becoming more common. Self-learning through materials that are available globally on information networks is also becoming more common, but it is difficult to demonstrate the acquired skills.

The envisioned technological transformation is based on computer-assisted and needs-based, gamified learning, in which the teacher's role is to mainly provide encouragement and support. In reverse learning, familiarisation with the topic takes place independently through online lectures or demonstrations on the topic and its fundamental elements. The various things that were learned and their meaning are weighed through discussions with the teacher and other students. The actual training in acquired skills takes place through simulations and exercises provided by learning games. Expertise is demonstrated by performing long, multi-phase tasks provided and verified by AI, as well as by coping with simulated virtual world situations or physical tasks organised by robots. Learning is a lifelong process and required by constant change.

After acquiring basic skills, learning mainly takes place in connection with work or hobbies whenever the situation so requires. Therefore, education is not stored, but acquired as situations arise. The emphasis in basic level is on structuring and perception skills and on skills related to meanings, problems and communication. A significant part of gamified learning and training takes place in peer groups through the solving of common problems. Artificial intelligence produces the necessary learning situations and guides and monitors learning.

Competences are identified independently of the organisers of education by demonstrating skills in a situation controlled by artificial intelligence. With the exception of cultural issues, the demonstration of skills is globally acceptable. In fast-changing areas, the proof of competence becomes obsolete and needs to be re-demonstrated periodically. Regarding proof of competence, it is irrelevant where the competence was acquired, whether it consisted of courses, independently read books or whether it was acquired through computer games. Informal demonstration of competence is becoming common alongside formal qualifications. It consists, for example, of peer reviews and customer feedback verified through block chains, as well as of standardised, assessed work performance.

Prerequisites for the transformation: The recent COVID-19 pandemic has shown that there are no significant technical barriers to the realisation of the vision. Learning materials and tests relevant to the vision are already widely available and the development work is ongoing. The overall service capability of information networks is also approaching the level required by the vision. The main obstacles to development are institutional and regulatory or related to customary values. Businesses and public administration generally require qualifications from educational establishments, often nationally validated. The right to award qualifications and the funding of studies for obtaining qualifications are generally linked to course-like teaching guided by traditional structures and habits. At the individual level, the vision requires neuroplasticity, continuous unlearning and the learning of new concepts and skills. In the Future Bank: flipped learning.

Agenda 2030 impacts: The best teachers are not available everywhere, but the best teaching and the best learning materials can be shared with anyone who has access to information networks. Poverty is in many ways the result of educational shortcomings. Therefore, a vision of learning opportunities accessible to everyone is one of the most effective means of eradicating poverty. Wide knowledge increases productivity, reduces costs and increases equal opportunities. In the best case scenario, the vision of freely available educational materials and gamified peer learning puts the motivated students in remote villages on a par with elite school students. In the vision, learning is not linked to the student's background or location. The envisioned learning environment also increases the motivation for learning. Situational and needs-based learning as the main means of lifelong learning contributes to continuous development at work and has innate immediate motivation and rewards through better work results.

It will be easier for girls and women to study and influencing opportunities will increase. Skills related to practical health, nutrition, legal protection and economic, social and ecological activities will be more easily accessible. Opportunities to learn on a case-by-case basis will increase innovation and facilitate the dissemination of new added value, especially in developing countries. The vision reduces the dependence of productivity differences caused by skills gaps on the capabilities and resources of public operators. Furthermore, the vision reduces dependence on so-called inherited sources of inequality, as degrees are not only granted by educational institutions accessible to the elite.

The vision increases local expertise and its importance in developing countries. It promotes civil liberties, access to information, the ability to acquire new technologies and develop communication structures and cooperation related to sustainable development.

Key tensions: The main tension threatening the vision is related to the existing structures. Decision-makers are involved in traditional qualification structures and educational institutions. The structures are primarily national, but similar in each country. Their fundamental change will not happen without significant pressure in the industrialised world, because developing countries alone will not be able to create the drivers of change. The separation of globally acceptable qualifications from the organisation of education is so far widely implemented only in technology-related micro-qualifications used in the business world. International cooperation networks between universities may, step by step, lead to a wider distinction between teaching and the demonstration of competence.

2.16 Producing experiences – towards robotised and virtual participatory experiences

Current state: The mainstream of entertainment is based on producing and consuming experiences. Books, magazines, TV series, films, music recordings, and concerts all accurately distinguish the producers of experiences from their consumers. Competitive sports, numerous other events, museums and exhibitions most commonly follow the same model, which more or less guides consumers to the role of a passive audience. There may be limited participation, but participation is deeper and more active in hobbies, dance, social media, online games and, in most cases, tourism.

The envisioned technological transformation is based on inclusive entertainment, where the participant in the experience is an active party who produces shared experiences for fellow human beings. In the vision, the future mainstream of entertainment is mainly seen to be digital and robotised. This takes into account limited natural resources and the production costs of individual experiences. Unlike the current screen time, virtual reality and robots will produce experiences of physical exercise such as flying or mountain hiking. Shared virtual reality makes it possible to share adventures with other people, with both old and new acquaintances.

Artificial intelligence produces experiential environments and stimulating events for them. We can enjoy the music by participating in the experience as a musician or roadie. We take part in cinematic stories as characters and experience reading an old book at the venues as a story told by an evening campfire or during a virtual camping trip. Combining gameplay and adventure can extend to learning hobbies, such as experiencing art as contemporary students of painters, or to tourism through events similar to those in adventure games. Experiencing nature by means of virtual safaris, dives, or space travel does not exclude sex robots or other aids that produce physical experiences in the virtual world and read and respond to the emotions of the person enjoying the experience.

The robots' role as the producers of gourmet experiences and as playmates, dance teachers, home violinists, painters decorating walls or organisers of social games and as butlers helps organise participatory experiences for a crowd that is physically present. AR glasses and avatar robots enable virtual presence as part of the physical reality. With the help of VR glasses and drones, for example, you can experience flying with Snoopy and the Red Baron. After that you can, for example, take a plunge over Niagara Falls in a barrel.

Prerequisites for the transformation: VR and AR glasses must develop and become more accurate and lightweight. Shared virtual reality and the tools related to experiencing it physically must develop. Entertainment and other production of experiences must continue to be oriented in the direction of games and inclusivity. Robotics providing experiential services must develop. In the Future Bank: VR glasses, AR glasses, 3D environment modelling, service robotics, digital experience platforms.

Agenda 2030 impacts: In developed countries in particular, the increasing technology related to experiences and the transformation into inclusive experiences generally reduces entertainment costs. The cost of electronics is minimal compared to the normal physical entertainment infrastructure. Participation through virtual reality also reduces the threshold for encounters. Online games bring together the rich and the poor, those who are healthy and those that are fatally ill and the citizens of wealthy Western countries and developing nations in a virtual world where they get to know each other over shared experiences.

Virtual encounters reduce the spread of infectious diseases and traffic accidents. Experiences involving learning have a very positive impact, both through training and insight. Knowledge is more easily transformed into skills through personal experimentation than through passive reading, listening or watching. Learning and insight in itself are significant experiences, and therefore a large part of the offered participatory experiences lead to learning interesting things. In the vision, this happens regardless of time and place.

As the entertainment industry directs its activities towards the vision, it offers various jobs to the builders of virtual worlds, robot maintainers, actors and supervisors of virtual roles, which are distributed culturally in exotic and interesting ways. This will promote the diffusion of innovation and create new added value for wider markets. Equality for women is enhanced by the virtual worlds' objective of creating experiments and independence from physical strength. The global nature of these activities reduces inequalities between countries. Inequality is also reduced by significant independence from physical infrastructure and bottleneck resources. Since added value is based on broad multicultural participation, technology reduces dependence on intangible rights and other privileges, while promoting global communication.

Key tensions: The transition of life and experiences into virtual worlds may alienate people from the physical reality and from the people in their immediate surroundings. Virtual reality can also reduce physical mobility and have the same effect as addictive drugs. The disappearing importance of the physical world can reduce participation in decision-making. Virtual worlds easily form their own closed bubbles, where the birth of cults, the spread of criminal thinking and threatening activities can spread easily. Virtual worlds can also become important for their users through friendships and due to sources of information. Platform providers may easily deprive people of these opportunities without the existing legal systems being able to intervene. In the virtual worlds or on social media, people do not have the familiar, legally guaranteed civil rights of the physical world.

2.17 Safety and security – towards individual and crowdsourced safety and security

Current state: In general, security means a regular, safe operating environment. It relies on state regulations, centralised supervision and other government activities. The more efficiently and flawlessly the authorities and the legal system operate, the more we rely on bodily integrity, protection of property, the safety of food, chemicals, electrical equipment and transport, privacy and the information we receive. However, the decentralisation of production and logistics, remote impact and the increasing complexity of societies make state-controlled monitoring more difficult. For example, ensuring information security is already largely the responsibility of citizens and peer reviews are trusted in an increasing number of areas.

The envisioned technological transformation is based on the widespread decentralisation of everyday control and crowdsourcing it at the citizen's level. The sensors of common smartphones of the future, such as material radars, artificial noses and 3D cameras, identify products and situations and assess their safety. The perception of safety is increasingly based on personal and crowdsourced experience rather than on safety standards. Crowdsourced peer-to-peer services work together with authorities to notify them of security incidents. A significant share of the security services available for personal use are global, as risks are increasingly global.

Security programs can be thought of as digital guardian angels. They monitor our own robots to prevent hijacking by hackers. They warn of dangerous situations in transport, people posing a threat, dangerous chemicals, biological risks and counterfeit products. Health threats, seizures and violence may generate a warning and a request for assistance to people in the vicinity or to rescue authorities. Autonomous cars and other equipment moving about in our surroundings can monitor each other and help identify hazards. The aim is to also identify any hazards in the virtual reality by identifying not only viruses and data breaches, but also threatening or misleading messages produced by machines and stolen or fake identities. Abuses may be recorded for the purpose of legal protection.

Prerequisites for the transformation: The vision will be realised gradually. Crowdsourced evaluation of services is already an important step towards the vision. Machine vision and environmental situational awareness develop through autonomous traffic, artificial noses and material scanners as part of biotechnology, medicine and the process industry. Crowdsourcing and cooperation between authorities require product development and changes in attitudes and regulations. In many situations, privacy laws may make it more difficult to identify the risks to individuals and to ensure security. In the Future Bank: material scanner, machine vision, biosensors, environmental detection, robot traffic, blockchains, GDPR.

Agenda 2030 impacts: Decentralisation and crowdsourcing of security will substantially reduce the costs of monitoring and increase the safety of all activities that are currently not monitored. The envisioned activities also increase flexibility in crisis situations and improve the equality of opportunities. The reliability of service production can be achieved without rigid regulatory approval. Self-monitoring by consumers and by small and medium-sized entrepreneurs and the crowdsourcing of risk information facilitate in particular the decentralisation of food supply, e-commerce, the decentralisation of goods production and personal services. Avoiding health problems, detecting illnesses and finding help will become easier. The significance of physical strength decreases as the detection of violence and oppression becomes easier. This increases women's equality.

Wide availability of risk information increases confidence in good operators, products and practices, while eliminating poor alternatives from the market. Decentralised trust facilitates market access for new products and operators and increases the opportunities for local operators to bypass well-known chains. This helps parties operating especially in developing countries. Wide and inclusive action to generate risk information and shared trust data increases empowerment, reduces productivity gaps and improves opportunities for safe mobility for all. It also reveals harmful activities and reduces environmental damage, violence, exploitation, crime and restrictions on freedom. Wide and reliable collection of risk data and crowdsourced response to it facilitate the emergence of all kinds of regional and international cooperation structures and reduces corruption.

Key tensions: Wide-ranging and versatile measuring instruments in the hands of citizens facilitate the collection of data in networks. The data must be combined so that AI can develop neural networks that separate risks from normal operations. Learning without collecting diverse observations is impossible when using the means of AI and pattern recognition. However, when collected, the same data can be used for many purposes that do not always comply with the ideas of those collecting it. Therefore, the risk related to this vision is that data will be used for wrong purposes. Due to the fear of this risk or the desire to strengthen the role of traditional controlled structures, states can, in practice, regulate the crowdsourcing of risk information so tightly that it provides no significant benefits to its users.

2.18 Collaboration and trust – towards voluntary work and international trust platforms

Current state: Currently, the ability to cooperate in a delayed exchange is mainly based on cultural norms, national institutions, the legal system and trust that agreements are adhered to. In repeated encounters, we trust that we understand the partner's own interests or the nature of the partner. We are also used to trusting the strongly marketed brands of large organisations and chains. Social media and increased international exchange have increased the importance of the reputation economy, crowdsourcing of trust and platform cooperation.

The envisioned technological transformation is based on increasing internationalisation of cooperation and on increasing complexity of transactions, which results in a situation where agreement structures and hierarchical trust systems are too rigid. Platforms that are independent of public authorities provide peer-to-peer experiences regarding each partner, product or service. Confidence in these, mainly international platforms, is based on transparent mechanisms and a belief in the authenticity of feedback. If platforms participate in transactions, there is also trust in their ability to protect privacy, impose sanctions and compensate for poor operations. In connection with platforms, we can talk about the reputation economy, where peer reviews or customer feedback build up the good or bad reputation of operators, products or services. We can talk about a social currency that accumulates like karma.

In addition to platforms, the ability to cooperate can also be increased, for example, by means of individual certificates. In the vision, transactions, products and service performances can be individually identified and their characteristics can be replicated in digital twins. This can be achieved, for example, by means of blockchains. Reliable identification facilitates sanctioning and reduces suspicions concerning the parties' claims related to, for example, the origin of products.

Digitalisation reduces transaction costs. Increased transparency facilitates cooperation and increases the importance of reputation. These promote cooperation through the means of the sharing economy and participation in, for example, intangible voluntary work, of which Wikipedia and Linux are familiar examples. According to the vision, non-monetary cooperation based on common interests will expand as transactions become more and more automated.

Prerequisites for the transformation: The vision will be realised gradually. Widespread implementation requires reliable authentication and a high level of data security of digital connections, as well as a continuous decrease in transaction costs per unit. The unique identification of products and the reliable recording of service events required by the vision requires the development and dissemination of methods designed for this purpose. In the Future Bank: peer trust, voluntary work platforms, identification of goods and services.

Agenda 2030 impacts: The vision lowers the threshold for participation in activities generating added value and economic benefits. Flexibility in crisis situations increases and complex bureaucracy in the trust structures of international trade decreases. The sharing economy will increase the volume of both food and non-food production in relation to the tied-up capital. The development of know-how is facilitated by intangible assets that are created through voluntary work and that can be freely shared. Peer trust makes it easier to find the best expertise. Increased equality of opportunities and peer feedback increase the motivation for learning. Increased peer knowledge reduces the risk of violence, corruption and other forms of crime, and increases the implementation of justice through improving the transparency of activities. Women's influencing opportunities increase.

The vision helps entrepreneurs, networks and customers especially in developing countries to grow their trust capital. The envisioned trust structures are most beneficial in countries with the weakest traditional trust structures and for parties seeking to penetrate markets occupied by traditional operators. There are also obvious benefits for local operators who are not part of the chains of large brands. Extending international trust networks to developing countries clearly increases both parties' willingness and ability to cooperate. The vision thus reduces inequalities both within and between countries and supports the implementation of sustainable development.

Key tensions: The collection of peer information is restricted by law. National authorities want to hold on to their role, carry out inspections and require the approval of any subcontractors used by public entities in line with traditional trust structures. Many of the vision's benefits may not be achieved in overlapping structures. Platforms that collect peer information may misuse the information they collect if their activities are not supervised or transparent.

2.19 Existential meaning – towards direct rewards for actions and community work

Current state: The meaning of life is a mystery, but in today's world it is very often experienced through internal rewards or duties. One's own position or status and those of loved ones, or power, wealth, health and reputation may feel rewarding. Obligations are strongest in the framework of one's own group identities, which include values, norms and rituals. This often involves a work or hobby community, other peer groups and people close to you. In an industrialised society familiar with the producer/consumer division, the objects of actions, such as customers, often play only an instrumental role, like competitors in sports that you just have to win. With the expansion of the network economy and sharing economy, boundaries are shifting. Customers are increasingly often not seen as a crowd, but rather as partners, and the existential meaning is changing from a competition to a more communal set-up.

In the envisioned technological transformation, digitalisation and robots have made work more holistic and meaning-oriented. Continuous virtual contact with loved ones creates a new type of grouping. Values have become more collective. Instead of being something or achieving something, shared activities have become rewarding. Group identity is experienced through the rewarding nature of this cooperation. The gamified creation of added value and the gathering of trust points among the network economy partners is starting to be more rewarding than competition for power or ensuring that you are in your supervisor's good books. A part in a great story is still important, but great stories are shifting from religious salvation or athletic achievement toward actions to overcome the great plagues of the world. What matters is not the position in an organisation, but the actions seen by others. For this reason, as transparency increases, it links both the perceived and the demonstrated identity more and more closely to real actions.

The experience of meaningfulness has been related to a mirror and the idea of the body as a temple. Social media or other communal feedback system with its thumbs up is the new mirror. When they are digitalised, hedonistic meanings cease to be a competition for material things and the benefits offered by them. Digitalisation also guides hedonism towards communal values. Robots easily produce everything except the appreciation of fellow human beings, which is hard to achieve without being helpful or bringing joy to others. A virtual castle produced for private use does not create much appreciation or satisfaction.

Prerequisites for the transformation: The fulfilment of the vision requires the decentralisation of production. The technology of individual production of goods and services must develop and the operating method must become more common. There must be an increase in the collaborative sharing economy and volunteer actions, and the role of the platform economy and the gamification of society must grow as the means for steering cooperation. In the Future Bank: artificial intelligence as a supervisor, gamification of cooperation, community platforms.

Agenda 2030 impacts: As the importance of work shifts towards value for customers and partners and thus towards cooperation instead of the currently common confrontational posture, the resilience of the economy and equal opportunities increases. Linking meaningfulness to common achievements instead of power or status reduces the risk of exclusion and increases inclusiveness. Communal motives improve the availability of learning materials and peer support as well as the attractiveness of learning. The gamification of society, together with communal motives, reduces environmental problems and facilitates, for example, the appropriate use of clean water.

Communal and collaborative, gamified meanings contribute to sustainable economic growth. Growth is manifested through the compensation of competence gaps as well as through new added customer value and innovations. Participation in major salvation stories increases the desire to prevent climate change and to focus on renewable resources. This will promote local operators and decentralised energy production, global communications and free, intangible factors of production that are created on a voluntary basis. These will reduce inequalities both between and within regions and increase participation.

The growing importance of community, which increases cooperation through gamification reduces the living space of corruption and crime, as well as all forms of violence in communities.

Key tensions: Communities can become culturally homogeneous and exclude diversity. As described by Emil Durkheim, tension arises between organic and mechanical solidarity. Are values born of similarity, or do they allow for differences, and is the value of cooperation deemed to be that everyone gets what they want from it or that everyone gets something that decision-makers consider important? The vision is deliberately written as the creation of intention in the ability to provide customers, partners and fellow human beings with the added value they want, because technological development is more oriented toward this direction than toward the return of tribalism. The envisioned orientation of identities and intentions makes it difficult to manage organisations. The management literature speaks of this as a challenge related to the Millennials.

2.20. Power structures – towards impact-based participatory decision-making

Current state: In most cases, organisational decision-making is hierarchical. Organisations collect information that is necessary for decision-making in its area of operations. Decisions are made in the manner determined by the organisation's decision-makers and the decision-making hierarchy. In public decision-making, power is divided between municipalities, states and regions. Politicians and officials who have won a majority in the elections make both practical decisions and many broader agreements, such as those made at the international level. In many cases, those most concerned are largely unable to influence the decision-making process. There is now a growing trend in public administration towards stakeholder involvement. In companies, customers are involved in product development, with cooperatives engaging them in other decision-making as well.

The envisioned technological transformation is based on a view where digitalisation generates more and more diversity, remote effects and reduces the location-dependency of cooperation. In an increasingly complex world, the principle of subsidiarity, whereby those affected participate in decision-making, is no longer achieved through a geographically distributed representative administration.

In the vision, those affected are more directly involved in decision-making concerning relevant topics. Regional democracy is replaced, for example, by thematic democracy. In companies, customers participate in the design of individual products or the representatives of the target group participate in wider product development. There is an increasing number of cooperative-type, sector-specific structures emerging, with the stakeholders involved in decision-making in relevant special areas. In the envisioned administration mode, public authorities compete with each other and citizens choose their own preferences, regardless of their physical location.

Stakeholder activation for decision-making takes place through crowdsourcing. The available options can be illustrated by gamified elements and by simulating functional dynamics. The methods of the platform economy enhance sector-specific participatory governance tasks and extend democracy to issues that are important to individuals. Preparatory responsibility for decisions will be given to relevant, non-organised stakeholders through crowdsourcing.

Prerequisites for the transformation: Some of society's activities have traditionally been carried out by the means referred to in the vision. Examples include funeral and insurance activities. There are no technical obstacles to the realisation of the vision. The increasing complexity of society has already led, for example, to a situation where it is difficult or impossible for municipal councils to understand the impact of different decisions in the municipal sector. It has therefore been necessary to delegate decision-making powers to the government and authorities in specific sectors. Stakeholder involvement is one solution. The expansion of gamification, the mass power generated through crowdsourcing, the increase in internationality, the emergence of platform cooperatives and co-development technologies, the decentralisation of production and artificial intelligence all contribute to the possibility of the envisioned development. In the Future Bank: gamification of society.

Agenda 2030 impacts: Inclusive thematic preparation of decisions reduces dependence on centrally controlled resources and increases the equality of opportunities. Wide participation in the development of food production and health care services raises awareness of choices and opportunities. Inclusion also reduces the risk of exclusion, increases motivation to learn and, when it involves women or is gender-neutral, increases women's influencing opportunities.

Stakeholder involvement reduces all types of damage to the living environment. By involving various interest groups in the decision-making process, innovative ideas may be provided concerning product and service development. At the same time, the needs of local or specific groups can be taken into account. Through the spread of knowledge, this also opens up opportunities for local subcontracting and service development. Wide international involvement through the platform economy mechanisms will improve, in particular, the communications infrastructure and logistics of developing countries, while lowering the cost related to meeting needs and launching production.

Developments in line with the vision contribute to the global harmonisation of laws and practices, help increase visibility of various externalities and contribute to the initiation of protection measures. Increased transparency and stakeholder influence result in a decrease in corruption and other forms of crime. Widespread involvement, both at the national level and on international platforms, facilitates international and domestic cooperation.

Key tensions: When it comes to power structures, tensions are natural and significant. The identity, skills or wealth of many decision-makers are based on some power structure. Many governmental structures stem from the constitutional level. On the other hand, the global platform economy, with Wikipedia as one example of it, demonstrates in new issues how great the power of inclusion can be. The content of activities is almost entirely shaped by the decisions of stakeholders and users, with the platform only acting as an enabler. Development is inevitably moving towards the vision, but regional and thematical hierarchical power structures can continue to operate centrally, as is demonstrated by the global world on a daily basis. It is also evident that the complexity of common issues can be such that it is difficult to understand their nature and effects. Yet you can easily talk about them in a compelling manner. Inclusion can also lead to major mistakes.

3. Crystallisation of the Agenda 2030 goals and goal-specific analysis of technology development

The technological transformation visions described in this report have been assessed against the UN Sustainable Development Goals (SDGs). Agenda 2030 is another name for these global Sustainable Development Goals (SDGs) set by the UN in 2015, which were approved by 193 countries at the time. The achievement of the goals is monitored at the UN level with 169 targets, in addition to which countries and regions have their own targets. The goals are summarised as follows (United Nations Statistical Commission 2017):

1) End poverty in all its forms everywhere
2) End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3) Ensure healthy lives and promote well-being for all at all ages
4) Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5) Achieve gender equality and empower all women and girls
6) Ensure access to water and sanitation for all
7) Ensure access to affordable, reliable, sustainable and modern energy
8) Promote inclusive and sustainable economic growth, employment and decent work for all
9) Build resilient infrastructure, promote sustainable industrialisation and foster innovation
10) Reduce inequality within and among countries
11) Make cities inclusive, safe, resilient and sustainable
12) Ensure sustainable consumption and production patterns
13) Take urgent action to combat climate change and its impacts
14) Conserve and sustainably use the oceans, seas and marine resources
15) Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16) Promote just, peaceful and inclusive societies
17) Revitalise the global partnership for sustainable development

The 169 targets that were referred to are not suitable for the purposes of this report as such, as the future cannot be measured directly and the impact of the means cannot be predicted without making assumptions. For this reason, each goal has been turned into a qualitative technology indicator that is suitable for making predictions and that justifiably promotes the achieving of the goal. These are derived from the 169 targets that have already been set. Each technology indicator selected for this purpose contains a crystallised assumption of how technology can contribute to the achievement of the sustainable development goal, as well as a series of questions that elaborate on this impact. Revenue-sharing and social decision-making with consequences that do not appear to be manifestly and significantly influenced by technology choices were not included in the technology indicators. This choice is the author's view, and when seeking a more detailed analysis or a more extensive analysis of the technological impact, one should use the original UN descriptions.

The indicators described here have been used in the assessment of technology transformation visions as the basis for impact assessment and in the summary report in order to assess the impact of each of the anticipated technological transformation on sustainable development as a whole. The impact of technologies has been assessed from a life-cycle perspective, unless otherwise stated.

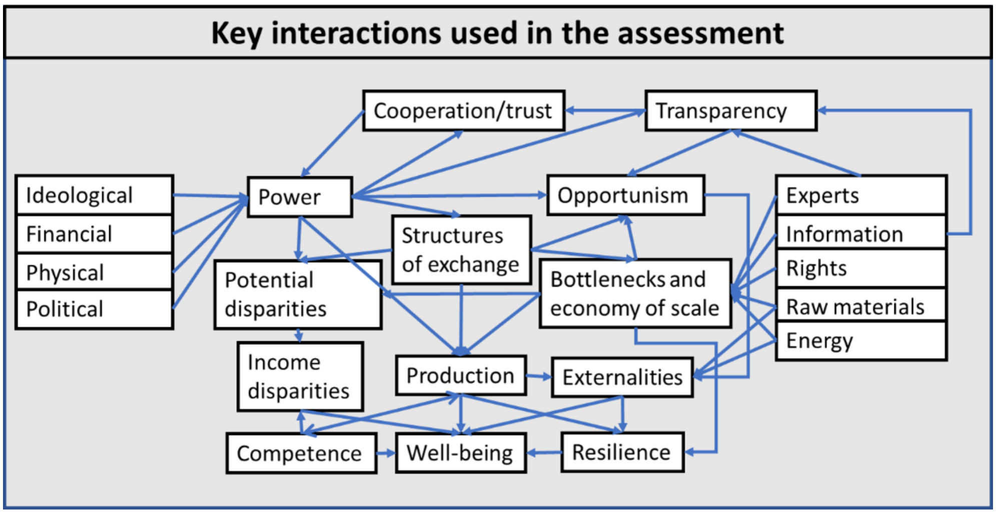

Figure 1: Some key causal relationships between the envisioned socio-technical systems and the Agenda 2030 goals and the technology indicators in this report

When analysing the impact of technological transformation on sustainable development, it is first necessary to develop an understanding of the current approach and the vision for a new model. In order to understand the change, attention should be paid to those socio-technical structures that have a particular impact on the sustainable development goals. One must therefore ask what types of issues in general affect, for example, production volumes, well-being, competence, inequality, externalities and the ability to cooperate. It is also important to understand the complexity of interactions. For example, an increase in energy efficiency does not necessarily reduce energy use and an increase in production does not necessarily reduce poverty. It should also be noted that a positive change related to one indicator may be detrimental from the point of view of another indicator, and revealing such effects is precisely why such a comprehensive set of indicators was created.

On one hand, production is influenced by factors of production and, on the other hand, by achievable economies of scale, all of which are realised as added value produced through exchange structures. The above graph includes information, rights, raw materials and energy as examples of production factors. In this review, they are only worthy of attention if their availability is limited by a bottleneck or economies of scale. Breathable air is an example of a necessary but generally ignored factor of production, as its use is usually unrestricted.

Externalities arise from opportunism, which is controlled by power structures and transparency. Opportunism is seen here as a broad concept which covers not only the actual abuses, but also those legal acts that are likely to cause externalities. Usually, such activities cause resentment when they become visible, and widespread resentment leads to changes in standards. Unconscious behaviour accepted by the majority of a community which is detrimental to many is also considered to be opportunistic action in this regard.

Externalities mean any damage caused to parties other than the contracting parties or those not involved in the activities. Typically these occur in the form of pollution, noise or the exhaustion of collective pastures, but also in the form of more dangerous living environments, such as road accidents, susceptibility to crime, exclusion, etc. Thus, an increased risk of nuclear war may be considered to be an externality of nuclear power plants (breeder reactors) and hybrid influencing an externality of social media. Disadvantages can be reduced by pricing them, prohibiting them or taxing them. Only drivers stemming from technology are considered here. Increased transparency is influenced, for example, by technology. It exposes externalities, which leads to their regulation. The same applies to opportunism.

There will be no prosperity without production and no production without technology. Technology also influences the distribution of prosperity and externalities. Inequality is influenced by the direction of production and the difference in purchasing power resulting from an unequal distribution of factors of production. For example, food prices have risen and inequalities have increased in developing countries as intensive farming takes over and focuses on export products. Income disparities arise mainly from structural reasons rather than from genetic differences. The resources or economies of scale needed for production are more readily available on the positive side of structures that cause potential disparities. Oil wells are a typical bottleneck resource and Google's search engine is a modern example of the benefits of economies of scale. The structures of exchange convert these valuable resources that are controlled by few into an abundance of less scarce, cheap resources of the other side of the potential disparity.

Adaptability, meaning resilience, depends on the flexibility of production, bottlenecks and externalities. Each of these can prevent effective adaptation to change if disadvantages or bottlenecks cannot be circumvented and there is no flexibility for change. Options typically increase resilience. Therefore, an increase in communication channels, for example, even if there is more chance of failure, increases tolerance of disruption. An alternative channel usually always works.

Power means the ability to control the structure that generates income disparities. According to Michael Mann's (1986) work, *The Sources of Social Power*, power is divided into military, political, ideological and economic power, the manifestations of which are abundant in the world. The mechanisms of power are diverse and socio-technical structures play an important role. However, power does not stem directly from socio-technical structures, but from cooperation around them. This can be seen, for example, in the context of revolutions. Power controls the structures of exchange, production bottlenecks, economies of scale and potential disparities. Cooperation, transparency and opportunism all influence power and power influences them.

Interactions are complex. The following crystallisations of the sustainable development goals relevant to the technological development and the questions selected as technology indicators have been written after more detailed consideration and by using the above as the general starting points. In creating them, all 169 targets that were defined by the UN and that are mainly performance indicators have been taken into account. Apart from a few exceptions, they do not discuss concrete means. However, when future technological transformations are assessed, it involves specifically assessments of the impacts of the means. The results must be predicted and thus causal assumptions must be made, which in this work, when defining the technology indicators, have been presented as qualitative questions. Estimates may be assigned either a positive or a negative sign depending on whether the effect increases or decreases sustainability. No value is given if the effect is unclear or the benefits are equal to the disadvantages.

The UN SDG links in the goal headings are links to the UN's own characterisation of each goal and the original goal-oriented Agenda 2030 targets with which these qualitative indicators of technology foresight can be compared.

3.1. Goal (UN SDG 1); end poverty in all its forms everywhere:

The main assumption is that the technology transformations will have an impact on the distribution of income primarily through the distribution of the availability of factors of production. The more balanced the distribution of control over the various factors of production and the smaller the personal differences in productivity are, the smaller the income inequalities.

Technology indicators used in the analysis: Does the technological transformation reduce dependence on scarce or centrally controlled resources? Does it improve the ratio of added value creation and capital employed? Does it reduce the variable costs of the creation of added value? Does the technological transformation increase the resilience of the economy in crisis situations? Does the technological transformation increase economic inclusiveness and the equality of opportunities?

Key technological transformations: It is estimated that any changes that are in line with the presented visions will reduce poverty. Based on the selected indicators, the following are estimated to have the greatest impacts: the progress of flexible and individual local production, cheap solar energy combined with decentralised energy reserves, improved conditions for self-sufficiency, the sharing economy and micro-entrepreneurship, progress of self-measured and crowdsourced AI data and AI-verified independent learning. The most evident impact is that all this promotes the possibilities that people in underdeveloped regions, those lacking access to education and people living in the shadow zones of industrial investments have in terms of improving their standard of living.

3.2 Goal (UN SDG 2); end hunger, achieve food security, and improved nutrition and promote sustainable agriculture:

New technologies can help increase the total volume of food production or increase it in areas where food security is at risk. Technological development can also reduce waste in food production, its dependence on resources and the disadvantages of agriculture. In addition, it can increase food security and the nutritiousness of food.

Technology indicators used in the analysis: Does the technological transformation increase food production? Does it reduce the capital intensity of food production or dependence on scarce resources? Does it reduce the production cost of nutritious food or the storage and trade costs of food production? Does the technological transformation reduce the environmental impacts of food production? Does it increase the resilience of food production in crisis situations? Does the technological transformation increase awareness of individual nutritional needs and the possibility to take them into account?

Key technological transformations: A number of the envisioned transformations contribute to the goal of eradicating hunger, improving nutrition and reducing the disadvantages of agriculture. The transformations with the largest impact are the shift towards cities that are self-sufficient in terms of food and individual food production and the robotisation of work and artificial intelligence providing services. The transformations towards a proactive approach to health and game-based self-diagnostics and self-measured and crowdsourced AI data are also important. The development of indoor farming implemented in a closed cycle with renewable energy and the development of biotechnological meat into notable and widespread sources of food is particularly promising.

3.3 Goal (UN SDG 3); ensure healthy lives and promote well-being for all at all ages:

Technology can promote access to health information and a healthy lifestyle. Technological development can also facilitate the detection of health problems and promote the availability of services with fewer or limited resources. Technological development can also change the nature of work tasks and studying so that they support mental well-being and it can reduce health damage caused by the living environment.

Technology indicators used in the analysis: Does the technological transformation facilitate access to general health information or will it contribute to the effectiveness of health information? Does it help expand diagnostic capabilities or access to medicines for populations currently excluded from health services? Does the technological transformation make treatment methods for serious illnesses more effective in a widely accessible way? Does it reduce mental problems caused by exclusion or other causes? Does it reduce the risk of accidents or communicable diseases? Does the technological transformation reduce environmental damage that is dangerous to humans? Does it promote healthy lifestyles, for example, in terms of nutrition and physical activity?

Key technological transformations: All envisioned transformations contribute, at least to a limited extent, to a healthy life and well-being, with the exception of robotisation of work and AI that offers services, which can have a major exclusionary effect especially during the transition phase. The most significant positive impact is estimated to stem from proactive self-diagnostics and the gamification of health. Autonomous electrified transport, individual fresh food in food self-sufficient cities, self-sufficiency, the sharing economy, technical aids for people with disabilities, increased direct observation and self-study, crowdsourced safety and security and increased direct rewards for actions also have significant impacts.

3.4 Goal (UN SDG 4); ensure inclusive and equitable quality education and promote lifelong learning opportunities for all:

New technologies can be used to provide effective access to learning materials, and appropriate advice can be found more easily where and when needed. Technology can also be used in an easily reproducible and accessible way in a learning event to train skills through simulation and robotics. Technology also helps overcome language barriers, develop motivation and demonstrate competence.

Technology indicators used in the analysis: Does the technological transformation make learning materials more widely available and accessible? Does the technological transformation facilitate self-study, self-directed training and the demonstration of competence? Does it make teaching less dependent on resources and location? Does it provide wider possibilities for peers or teachers to support learning? Does technology make learning more attractive or easier?

Key technological transformations: Promoting telepresence and virtual encounters, the robotisation of work and AI that provides services, direct measurement and crowdsourced AI data, as well as AI-verified independent learning are the most important transformation visions that contribute to the achievement of the goal.

Other relevant transformations include the development of personalised local production, gamified self-diagnostics, and virtual participatory experiences.

3.5 Goal (UN SDG 5); achieve gender equality and empower all women and girls:

New technologies may be more readily available to women due to cultural, religious or physical reasons or reasons related to status. Technology can reduce violence and oppression against women. It may also reduce the relevance of gender roles concerning the distribution of activities and ownership in an economically unequal way.

Technology indicators used in the analysis: Does the technological transformation reduce the importance of physical strength? Does it overtake technology that has been socioeconomically dominated by males? Does the technological transformation reduce the risk of violence and repression? Does the technological transformation increase the opportunities for girls and women to acquire knowledge? Does it increase the social empowerment of girls and women regardless of power structures?

Key technological transformations: It is estimated that the main contribution to gender equality will continue to be made by machines replacing manual labour. The development of autonomous transport, telepresence, functional assistance, independent learning, collective safety and security and trust platforms is also seen as having a significant impact. However, the development of the self-sufficiency can increase the importance of physical strength and increase the risk of repression due to isolation.

3.6 Goal (UN SDG 6); ensure access to water and sanitation for all:

Technology can facilitate access to clean water, especially in water-scarce areas, and improve the sustainable use of water. Technology can also promote sanitation opportunities, improve hygiene and help identify problems in this field.

Technology indicators used in the analysis: Does the technological transformation help produce clean water in areas suffering from a lack thereof? Does it help identify or eliminate pollutants in water intended for human consumption or in waste water and does it help identify or eliminate the resulting problems? Does it help use and distribute water more efficiently or appropriately? Does the technological transformation improve sanitation and hygiene in areas suffering from shortages? Does it improve the sustainability of aquatic ecosystems?

Key technological transformations: The development of cities that are self-sufficient in terms of food is the most important vision for promoting access to water, as indoor farming requires little water and the closed cycle of indoor farming does not pollute the waterways. Other developments that are deemed relevant include measured and crowdsourced AI data, which, among other things, helps detect contaminated water. For the same reason, the trend towards individual and crowdsourced safety and security is seen as an essential vision, when assessed based on the indicators. The transformation of power structures towards participatory decision-making is also likely to have a positive impact on actions related to access to water, sustainable use of water and sanitation.

3.7 Goal (UN SDG 7); ensure access to affordable, reliable, sustainable and modern energy:

Technological development can enable low-cost energy production locally, facilitate and enhance the distribution and storage of energy and the reliability of energy supply. Energy technology can become increasingly harmless and less capital-intensive. In particular, this development may lead to non-carbon primary energy generally becoming cheaper than fossil-based energy production methods and thus drive them out of the market.

Technology indicators used in the analysis: Does the technological transformation reduce the environmental impacts of energy production? Does the technological transformation reduce the capital, concentration and skills requirements for sustainable energy production? Does it reduce dependence on fossil sources of energy? Does it improve the energy efficiency of processes or replace them with more sustainable ones? Does the technological transformation make it easier to obtain affordable and sustainable energy in areas with infrastructure deficiencies?

Key technological transformations: It is clear that the most important transformation vision is the trend towards cheap solar energy and decentralised energy reserves. The impact is very positive regarding all of the criteria. The electrification of transport will also have a major impact, both when disengaging from fossil energy and in terms of energy efficiency. Other relevant developments include renewable materials that are independent of fossil energy sources, cities as autonomous housing machines favouring recycling and the transformation vision of self-sufficiency, the sharing economy and micro-entrepreneurship.

3.8 Goal (UN SDG 8); promote inclusive and sustainable economic growth, employment and decent work for all:

Technology can contribute to economic growth by producing something more or better, with fewer limited resources and with fewer externalities. Economic growth will be widely distributed if the productivity gains of technology are channelled to households or if the new methods are sufficiently labour-intensive. This is particularly the case if innovations help decentralise production or if the concentration created through economies of scale will otherwise be opened up to competition and if it only has limited market power. Thus, as a result of price competition, the benefits of the reform may be distributed evenly to the decentralised parts of value creation directly to customers or close to the customer interface and a large number of employees.

Technology indicators used in the analysis: Does the technological transformation help increase workers' productivity on a broad and decentralised basis or create and finance innovation? Does it help developing countries achieve the productivity levels of developed countries despite infrastructure and competence deficiencies? Does the technological transformation generate significant new added value for customers in large markets? Does it result in savings in costs other than labour costs or is the required investment distributed and labour-intensive, for example, by increasing individual added value or through savings in other capital-intensive costs and the use of capital-intensive services? Does the technological transformation reduce the use of bottleneck resources and externalities?

Key technological transformations: The most important of the envisioned transformations include the development towards individual local production, distance selling and digitalised transaction platforms, telepresence and virtual meeting places, as well as independent learning verified by AI. All this contributes to the decentralisation of work and eliminates bottlenecks and the importance of power structures. The majority of the other transformation visions significantly improves the conditions for growth, especially in emerging economies. However, cities as autonomous housing machines may increase inequality, and the same applies to the robotisation of work and AI providing services. According to the technology indicators, these developments have many positive effects on economic growth, but they also substitute human labour to a great extent, which may not be compensated by new jobs in growth sectors.

3.9 Goal (UN SDG 9); build resilient infrastructure, promote sustainable industrialisation and foster innovation:

Technological development can reduce the use of scarce resources in infrastructure projects, infrastructure maintenance and industry. A transition can be made to renewable materials, to structures using less materials and to the use of renewable raw materials and industrial processes that generate no externalities. Tangible and intangible infrastructures can be implemented and made easily accessible to all, especially to small-scale industry and innovative operators.

Technology indicators used in the analysis: Does the technological transformation promote a shift in production towards the use of renewable resources? Does it contribute in particular to the development of factors of production in the least developed countries and regions? Does it promote access to infrastructure services, including financing, procurement and distribution channels, for small-scale industry and innovative operators? Does the technological transformation in other ways promote sustainable and inclusive industrialisation, particularly in developing countries? Does it help increase the volume of R&D activities by facilitating the exploitation of research data?

Key technological transformations: A major transformation vision promoting sustainable industry is the trend towards low-cost solar energy, which will contribute in particular to the industrialisation of the least developed countries and the transition to the use of renewable resources. In addition, significant developments include robotised individual transport, flexible individual local production, renewable materials, robotisation of work, independent learning verified by AI, crowdsourced safety and security and trust platforms.

3.10 Goal (UN SDG 10); reduce inequality within and among countries:

As technology evolves, it can help reduce gaps in skills and productivity and promote broad access to knowledge and production factors. New technologies can also help meet needs in a way that utilises limited production factors only to a small extent and makes it cheaper to satisfy needs. Efficient logistics and communication reduce the dependence of value creation on location. In this way, they increase the equality of economic opportunities between countries.

Technology indicators used in the analysis: Does the technology transformation improve and standardise global communications and logistics in an inclusive way? Does it reduce differences in funding, skills and productivity that depend on government infrastructures? Does it reduce the dependence of value creation on concentrated factors of production? Does it reduce the use of limited resources that are controlled as bottlenecks? Does it reduce the cost of satisfying needs or starting production? Does it reduce dependence on intangible rights and other privileges that create inequality? Does the technological transformation promote the global harmonisation of equal laws and practices?

Key technological transformations: Cheap solar energy, decentralised energy reserves and telepresence are expected to be the most relevant visions when it comes to reducing inequality. Numerous other developments also appear to be important, such as the envisioned transformation of transport, goods production and food production. Distance selling, artificial intelligence for services, education and direct data collection, self-diagnostics, trust platforms and impact-based participatory decision-making also appear as important visions related to the indicators.

3.11 Goal (UN SDG 11); make cities inclusive, safe, resilient and sustainable:

New technologies can promote affordable housing, access to mobility for all, green spaces and public spaces in work and business areas. In addition, technological development can improve the resilience of residential areas in crisis situations, such as water shortages, recession or pandemics. The safety of cities and other residential areas can be improved and the environmental burden reduced, and inclusive links between cities and surrounding areas strengthened.

Technology indicators used in the analysis: Does the technological transformation facilitate the construction or maintenance of affordable housing and infrastructure accessible in the commuter area? Does it improve safety or easily accessible mobility for all? Does the technological transformation reduce the vulnerability of cities and communities in crisis situations or the environmental burden? Does the technological transformation increase the bonds of citizens and the environment or involvement in urban planning? Does it facilitate the use of local know-how and materials in developing countries?

Key technological transformations: Safe and sustainable cities are best created through autonomous electronic passenger transport, the trend towards cities as autonomous housing machines and individual crowdsourced safety and security. In addition, the following are important: robotised individual transport and loading of goods, telepresence, robotisation of work and artificial intelligence services, technical aids for humans, independent AI-assisted measurement and learning and direct rewards for actions as a central and general source of intentionality.

3.12 Goal (UN SDG 12); ensure sustainable consumption and production patterns:

Production and consumption patterns are sustainable when they do not overburden nature. Technological development can help reduce waste and improve the efficiency and recycling of raw materials. In addition, new technologies can replace limited resources with renewable resources and reduce the use of environmentally harmful chemicals and the spreading of such chemicals and waste into the environment. Technological development can also be used to raise public awareness of sustainable development and to monitor the realisation of the objectives.

Technology indicators used in the analysis: Does the technological transformation raise awareness of the mechanisms of sustainable development? Does it improve the local or global competitiveness of renewable raw materials or recycling? Does the technological transformation reduce environmentally harmful emissions or make more efficient use of limited resources? Will it make it easier to make environmentally damaging consumption, tourism and production visible in a way that does not reduce employment? Does the technological transformation support local knowledge, culture and employment in a way that promotes sustainable development?

Key technological transformations: The most significant transformation visions are cities that are self-sufficient in terms of food, that is, indoor farming and the trend towards renewable materials and the circular economy. According to the indicators, autonomous electronic transport as a service, robotic transport of goods, cheap solar energy, cities as autonomous housing machines, direct measurement and crowdsourcing assisted by artificial intelligence, robotised and virtual experiences, crowdsourced safety and security and direct rewards of actions are also important.

3.13 Goal (UN SDG 13); take urgent action to combat climate change and its impacts:

Climate change is mainly caused by greenhouse gas emissions from energy production, agriculture, industry, transport and buildings, as well as by the reduction of greenhouse gas sinks. Technological development can be used to promote the increasing awareness of the need for and benefits of solutions. Means to increase sinks and reduce emissions will also be promoted by facilitating funding and decision-making. The technological transformation can also contribute to decision-making that promotes the adaptation of societies or nature to the changing climate. In addition to raising awareness, the most important factor in speeding up decision-making is the attractiveness or acceptability of sustainable alternatives.

Technology indicators used in the analysis: Does the technological transformation increase the resilience and adaptability of societies in the conditions created by climate change? Does the technological transformation facilitate regulatory actions in communities and society aiming to slow down climate change and detect phenomena early? Does it contribute to the financing of rapid action to combat climate change in developing countries? Does it promote the transparency, planning and effectiveness of climate action?

Key technological transformations: The main transformation vision related to this objective is the trend towards cheap solar energy and decentralised energy reserves. Other significant developments supporting this goal include e-transport as a service, cities that are self-sufficient in terms of food, renewable materials, cities as autonomous housing machines, crowdsourced AI data, safety and security and AI-verified learning. All this contributes to either centralised or decentralised decision-making by providing information or direction and means to influence the change. The transition towards the subsistence economy could have a significant negative impact on the fight against climate change, unless the trend is based on closed-loop indoor cultivation and renewable energy and material technologies.

3.14 Goal (UN SDG 14); conserve and sustainably use the oceans, seas and marine resources:

Marine resources are affected in particular by acidification due to rising CO_2 concentrations, nutrient shortages caused by warming and expansion of the thermocline, waste and chemical emissions, and overfishing. Technological development can promote sustainable maritime transport and fishing. Technological means can also be used to reduce CO_2 emissions and reduce their concentration by capturing CO_2 from the atmosphere or water. In addition, the discharge of waste, nutrients and chemicals into the sea can be reduced and they can be collected from the sea through the development and use of new technologies.

Technology indicators used in the analysis: Does the technological transformation help reduce marine pollution? Does it help reduce CO_2 emissions and ocean acidification? Does it help reduce the nutrient loading of oceans? Does the technological transformation contribute to the sustainability of coastal ecosystems? Does it help control and reduce overfishing? Does the technological transformation contribute to research related to marine technology and marine ecosystems or does it contribute to marine biodiversity? Does it promote the market penetration of small fishing units?

Key technological transformations: Without other decisions taken by societies, these visions will not have a decisive impact on the conservation and sustainable use of marine resources. However, a number of transformation visions offer clear ways forward, which can be decisive when implemented in addition to other actions taken by societies. Renewable forms of energy, renewable materials and electrification of transport reduce ocean acidification. The robotisation of work will help reduce the amount of waste in oceans. Closed-cycle indoor farming in food self-sufficient cities contributes to the sustainability of oceans and coastal ecosystems, and the same applies to direct measurements and crowdsourced AI data. The development of independent learning and impact-based inclusion are also ways to promote this objective.

3.15 Goal (UN SDG 15); protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss:

Terrestrial ecosystems are threatened by the expansion of agricultural land, the impoverishment of managed forests, the spread of invasive species, poaching, pollution and desertification. Technology can help reduce these problems and reverse the trend in a more positive direction.

Technology indicators used in the analysis: Does the technological change help preserve or restore terrestrial and inland water ecosystems? Does it promote the sustainable use of ecosystems, the growth of forest area or the monitoring of sustainable use and conservation measures? Does the technological change help combat desertification, restore soil vitality, increase biodiversity and reduce extinction? Does it help make the state of ecosystems transparent and develop planning processes in conjunction with poverty reduction objectives?

Key technological transformations: The most important transformation vision for the protection and restoration of terrestrial ecosystems is a city that is self-sufficient in terms of food, as it eliminates most agricultural emissions and allows the majority of agricultural land to be restored to its natural state. Important means also include the robotisation of work, which enables the efficient implementation of recycling, mechanical weeding and reforestation. AI-verified learning and crowdsourced metrics also contribute to the same goal. However, the transition to self-sufficiency may have a significant negative impact on the objective.

3.16 Goal (UN SDG 16); promote just, peaceful and inclusive societies:

Peace is enhanced by a sense of justice, a lack of exclusion, safety nets, equality of opportunities, a lack of confrontation, transparency of abuses and legal realisation of responsibility. Technology can help increase transparency and the effectiveness of key institutions, prevent exclusion and increase inclusion and the meaningfulness of life.

Technology indicators used in the analysis: Does the technological transformation help reduce violence or the threat of violence? Does it help reduce repression, exploitation and human trafficking? Does the technological transformation facilitate access to the legal system and does it facilitate justice? Does it help reduce organised crime or the impact of crime? Does the technological transformation increase the transparency of organised activities and reduce the risk of corruption? Does it increase opportunities for participation at different levels of decision-making? Does the technological transformation promote civil liberties and citizens' access to information?

Key technological transformations: The most important transformation visions are self-measured and crowdsourced AI data, safety and security, which help especially in those areas where people's integrity and legal protection are most at risk. Other important promoters of the goal include autonomous passenger transport, distance selling and digitalisation of transactions, robotisation of work, proactive self-diagnostics, independent learning supported by AI, international trust platforms, direct rewards of cooperation and impact-based inclusion. Robotisation of personal package transport and remote impact represent a clear safety risk if the operations are poorly controlled.

3.17. Goal (UN SDG 17); revitalize the global partnership for sustainable development:

Cooperation between states has an impact on the global implementation of sustainable development. A key element of progress is that developed countries increasingly start making resources and skills available to less developed countries. The skills package includes scientific, technological and innovation competence, financial, export and communication competence, knowledge of sustainable development goals and means, efficient cooperation organisations and good national statistics.

Technology indicators used in the analysis: Does the technological transformation contribute to the developing countries' ability to acquire technological and innovation expertise? Does it encourage the willingness of developed countries to support the financing possibilities of sustainable development projects in developing countries? Does it promote or facilitate the economic and communication structures in developing countries or does it facilitate the development of such structures? Does it promote the emergence of national cooperation structures for sustainable development? Does the technological transformation facilitate the monitoring of the sustainable development goals and related statistics and international knowledge exchange?

Key technological transformations: The most significant factors contributing to the achievement of the goal are the transformation visions of independent learning verified by AI and self-measured, crowdsourced AI data. It is hardly surprising that knowledge and information are the keys to cooperation and implementation related to sustainable development. Other important factors include the physical, collective enablers of economic development, such as the robotisation of passenger and freight transport, cheap solar energy, cities as autonomous housing machines and the robotisation of work. Crowdsourcing of safety and security, international trust platforms and distance selling also create the conditions for effective implementation of sustainable development and global partnerships. However, increasing self-sufficiency makes collective objectives more difficult.

4. Summary

The purpose of the report is to describe 20 technological transformation visions and assess the societal impact of the visions from the perspective of the UN 2030 Agenda for Sustainable Development. A method was developed for this evaluation in order to anticipate the achievement of the objectives through each of the proposed technology policy trends or means. The results can be summarised as presented in Table 1 on the following page.

From left to right: **Technology transformations in value creation networks** From top to bottom: **Agenda 2030 goals**	Passenger transport	Logistics	Manufacturing of goods	Sustenance	Energy supply	Materials	Built environment	Exchange	Remote impact	Automation of work	Work and income	Healthcare	Redressing disabilities	Acquiring information	Proficiency and its proof	Producing experiences	Safety and security	Collaboration and trust	Existential meaning	Power structures	**Scope of technology solutions**
1. End poverty in all its forms everywhere	3	3	10	3	10	3	1	3	3	3	10	3	3	3	10	1	1	3	1	1	**3.9**
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture	0	1	0	10	1	1	1	1	0	10	1	3	0	3	1	0	1	1	1	1	**1.9**
3. Ensure healthy lives and promote well-being for all at all ages	3	1	1	3	1	1	1	1	1	-3	3	10	3	3	3	1	3	1	3	1	**2.1**
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	1	1	3	3	1	0	1	3	10	10	3	3	1	10	10	3	0	3	3	1	**3.5**
5. Achieve gender equality and empower all women and girls	3	1	1	1	1	1	1	1	3	10	-1	1	3	1	3	1	3	3	1	1	**2.0**
6. Ensure access to water and sanitation for all	0	0	0	10	1	1	1	0	0	1	0	1	0	3	1	0	3	1	1	3	**1.4**
7. Ensure access to affordable, reliable, sustainable and modern energy	10	1	1	-1	10	3	3	1	1	-1	3	0	0	1	1	0	1	1	1	1	**1.9**
8. Promote inclusive and sustainable economic growth, employment and decent work for all	3	3	10	3	3	3	-1	10	10	3	1	3	3	3	10	3	1	3	3	1	**3.9**
9. Build resilient infrastructure, promote sustainable industrialisation and foster innovation	1	3	3	1	10	3	1	1	0	3	3	1	1	1	3	1	3	3	3	1	**2.3**
10. Reduce inequality within and among countries	3	3	3	3	10	1	1	3	10	3	3	3	3	3	3	3	1	3	3	3	**3.4**
11. Make cities inclusive, safe, resilient and sustainable	10	3	1	1	1	1	10	1	3	3	3	1	3	3	3	1	10	1	3	1	**3.2**
12. Ensure sustainable consumption and production patterns	3	3	1	10	3	10	3	1	1	1	1	1	1	3	1	3	3	1	3	1	**2.7**
13. Take urgent action to combat climate change and its impacts	3	1	1	3	10	3	3	1	1	1	-1	1	1	3	3	1	3	1	3	1	**2.2**
14. Conserve and sustainably use the oceans, seas and marine resources	1	1	0	3	1	1	1	1	0	1	-1	0	0	3	3	0	1	1	1	3	**1.1**
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	0	-1	0	10	-1	1	1	1	1	3	-3	0	0	3	3	1	1	1	3	1	**1.3**
16. Promote just, peaceful and inclusive societies	3	-3	-1	0	1	0	1	3	-3	3	1	3	1	10	3	-1	10	3	3	3	**2.0**
17. Revitalise the global partnership for sustainable development	3	3	1	1	3	1	3	3	3	3	-3	1	0	10	10	1	3	3	1	1	**2.6**
Effectiveness of the technological transformations in relation to the 2030 Agenda goals	**2.94**	**1.41**	**2.06**	**3.76**	**3.88**	**2.00**	**1.88**	**2.06**	**2.59**	**3.18**	**1.35**	**2.06**	**1.35**	**3.88**	**4.18**	**1.12**	**2.82**	**1.94**	**2.18**	**1.47**	

Table 1. Technological measurement of the sustainable development goals by transformation vision. Assessment markings: (+/-) 1 = clear limited relevance; (+/-) 3 = partial decisive or broad relevance; (+/-) 10 = decisive actual or potential relevance.

In Table 1, the technology transformation visions have been assessed against each of the Agenda 2030 goals in terms of their detrimental or positive impact. This is a summary table, with the indicated values taking into account the assessments of the indicators related to each objective, i.e. the detailed qualitative questions.

A more extensive table with ancillary questions clarifying each of the goals is provided in Appendix 1 of the electronic version of this document.

The foresight results obtained with the method indicate that all 20 visions contribute to sustainable development in many different ways if implemented. Some may also hinder the achievement of the objectives in some respects. Poverty eradication, learning opportunities, economic growth, reducing inequalities and developing safe cities were expected to benefit significantly from several of the visions presented. The support provided by the visions was the narrowest for water security and the protection of aquatic and terrestrial ecosystems. However, there were also significant positive effects concerning them, and the impact was even seen to be decisive for terrestrial ecosystems and water security.

The total scores summed by rows or columns in the table cannot be directly compared with each other. As the scoring of individual cells is thematically proportional, the sum does not provide a fully comparable absolute value for the overall significance. Instead of general significance, it indicates the comprehensive nature of significant support.

In the evaluation, the visions having the largest comprehensive significance were the trend towards food self-sufficient cities, cheap solar energy and decentralised energy reserves, robotisation of work and AI providing services, self-measured and crowdsourced AI data and the trend towards AI-verified independent learning. The following had the narrowest impact on sustainable development as a whole: the trend towards robotised individual transport and loading, self-sufficiency, sharing and micro-entrepreneurship, technical assistance for people with disabilities, robotised and virtual inclusive experiences and the trend towards inclusive, impact-based decision-making. However, each of these was expected to have a significant positive impact on a number of sustainable development goals.

The compliance of radical technology transformation visions with the 2030 Agenda has not previously been systematically assessed. The Agenda 2030 goals or targets are not directly suitable for the assessment of radical transformation visions without a causal interpretative framework that establishes a link between the means and the goals. A new method was therefore developed for this work. As the results are method-dependent and such a method may be of wider use in the steering of technology policies, it is essential to assess the method, its nature and its limitations.

When evaluating the method, attention must first be paid to the fact that it involves the evaluation of future visions. This method is not suitable, and perhaps no method is suitable, for anticipating the full impact of individual radical technologies. Most technologies can be used in a wide variety of ways, as we can see, for example, from the many different ways in which Europe, the USA, Russia and China operate. The impacts are not so much the characteristics of the technologies themselves. They are consequences linked to the various methods of use that are created through interaction between society and diverse, simultaneously developing technologies. Thus, technologies enable various methods of use and diverse social systems. These social systems must first be envisioned and only then can they be assessed.

The predicted visions are either credible and possible developments, or unrealistic visions of the future, such as utopias and dystopias. There is no point in seriously assessing the impacts of unrealistic visions. The visions must first be formed and analysed in terms of the prerequisites for their realisation. Impact assessments must be carried out for goal-oriented or otherwise foreseeable visions that are sufficiently credible and likely in terms of technology, the economy and politics. An analysis of the likely operating methods stemming from technologies has been carried out in the report Societal transformation 2018–2037. The visions assessed here are based on technology transformations that were summarised in that report and in previous work and that have been considered to be credible.

On the basis of the 20 separate assessments in this work, the developed method can be deemed generally suitable for assessing the impact of systemic technology transformation visions with validated credibility. Overall, the impact assessment of technologies carried out in this way is a cumbersome process, but there is a risk of errors if shortcuts are taken. Setting an impossible direction as an objective is the biggest mistake.

Regarding the method used here, it is important to note that the subject in all its complexity is almost literally encompassing the worlds. The survey project was carried out with limited resources and, although the results are encouraging and show many trends worth pursuing, the results should be viewed only as preliminary findings. The method requires further development, evaluations require more diverse interpretations and, in addition to goal-oriented visions, more extensive dystopian descriptions than those referred to are required.

In order for assessments such as this report to be based on future opportunities and not just on prejudices, it is necessary to ensure that evaluators and visionaries are sufficiently involved in and understand the expected technological developments. This is a pluralistic and multidisciplinary task, which has been systematically promoted in the series of reports. The most extensive and systemic technology transformation visions presented here were discussed and their credibility analysed in the Societal transformation 2018–2037 report. The same groundwork can also be used to assess the technological and societal credibility of other transformation visions. An example is the recently published report in the series, which uses the same societal value creation network framework to assess the socio-technical impact of the coronavirus pandemic.

Technology used by societies has caused many of the world's problems. No new technology in itself will solve these problems. But technologies used in new ways make it possible to solve even complicated problems and to strive for sustainable development. It is also very important to recognise that solutions to various problems can be credibly considered in a comprehensive manner. If individual problems are solved and individual objectives pursued, it easily creates new problems or exacerbates existing ones.

The wider and more tricky the problems, the more comprehensive and methodical analysis is required for the planned solutions. The UN Sustainable Development Goals are ambitious, but we can move toward them, and they do not seem to contradict each other in a way that cannot be resolved. If implemented, the visions in this report will eliminate most poverty, disease, crime, inequality, skills shortages and environmental problems. The world can become sustainably a better place than it is today.

Appendix 1.

Detailed assessment of the technology transformation visions from
the perspective of the sustainable development goals

The Appendix is only included in the digital version of the original Finnish report on the page 71.:

https://www.eduskunta.fi/FI/naineduskuntatoimii/julkaisut/Documents/tuvj_5+2020.pdf