

Management Summary

# Technology Outlook

Future-oriented technologies for Switzerland

2023

# SATW Technology Outlook

The Swiss Academy of Engineering Sciences SATW is involved in early identification of technologies (in short: foresight) on behalf of the Swiss Confederation. Technology Outlook is a result of these foresight activities and presents future-oriented technologies that will be of relevance to Switzerland in the coming years. As a unique expert organisation with high credibility, SATW provides independent, objective and holistic information on technology – as a basis for establishing informed opinions. It is politically independent and non-commercial.

The speed of technological change makes it difficult to see the future clearly. Technology Outlook provides orientation in the technological landscape of tomorrow. It is a travel guide for the future, explaining trends in technology, ranking their importance for Switzerland as a centre of knowledge and industry, and comparing developments in Switzerland with those abroad. Technology Outlook identifies opportunities and challenges, and is thus an important basis for strategic work in industry and administration, as well as for location promotion agencies.

This management summary offers an overview of technologies' significance for Switzerland and addresses opportunities for the country as a location for research and business. It presents selected showcases from Swiss industry, provides insight into four specifically chosen technologies, and addresses the most significant national and international trends. Technology Outlook is based on interviews with 183 experts from 89 institutions.

**183**  
experts

**89**  
institutions

**32**  
technologies

**22**  
showcases

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Discover the central knowledge platform for Switzerland as a business location, with detailed texts on technologies and showcases, as well as national and international trends, at [technology-outlook.ch](https://technology-outlook.ch). The website offers you an exclusive opportunity to compile an individualised copy of Technology Outlook and download it as a PDF.



# Technologies and society

Technologies will play an essential role in the world of tomorrow. The following core statements are from a survey of an interdisciplinary group of 94 experts, on the impact of technologies on society.

An advanced healthcare system requires trust. To an increasing extent, particularly sensitive data will be needed for the medicine of the future. The survey clearly showed that the experts mainly consider it the Swiss Confederation's and cantons' duty to develop modern data-use guidelines that meet data-protection requirements. At the same time though, these should also facilitate simple and comprehensible exchange of data for research. The contribution to be made by institutions in the healthcare system consists of gaining and maintaining the population's trust. This includes comprehensible regulations on self-determined use of personal data.

Energy supply: security before costs. The experts rated security of supply, technological security and carbon neutrality as significantly more important goals than the other three: intact landscapes, maximum self-sufficiency and low-cost energy. In addition, the survey participants believe that acceptance of additional energy costs is lower when their purpose is to increase self-sufficiency than when they are for reducing the carbon footprint. Responsibility for a secure energy supply is seen to reside with energy companies, the Swiss Confederation and the cantons, more than it being private individuals' responsibility to save energy. Science should contribute to a sustainable energy supply by researching new energy sources and developing energy-saving equipment.

When it comes to materials, there is a need for knowledge, as materials are closely linked to ecological, economic and social contexts. The experts consider broad-based knowledge transfer in schools and information campaigns to be the most effective measures in this regard. Furthermore, there is a need to close reusable material cycles. The experts see taxation instruments as suitable measures with which to establish resource cycles. There is disagreement among the experts on whether the public is willing to accept additional costs for more sustainable materials.

# National trends

In total, 19 of the technologies that were shown in the first four-quadrant diagram in 2019 are represented again in 2023. It is enlightening to compare how their positions have changed in the years between the publications. For many technologies, striking positional changes are evident.

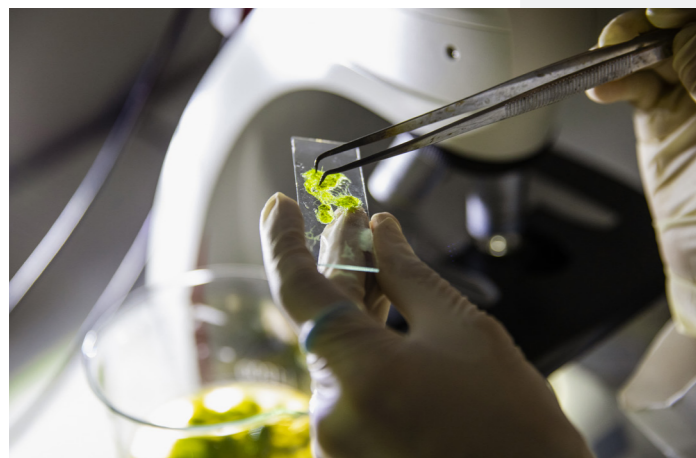
Swiss firms' sales revenue is the main determining factor of their economic importance. Thus, a change in position to the right is usually a result of an increase in sales revenue, i.e. industrial activity. In particular, quantum and post-quantum cryptography, alternative protein sources and point-of-care testing show major shifts to the right. The research competence value is determined by the number of academic and industrial research groups in Switzerland. A shift upwards can thus be due to academic and/or industrial factors. In all cases except point-of-care testing and quantum and post-quantum cryptography, an increase in the number of industrial research groups has led to increased research competence. Accordingly, the increasing significance of technologies for Switzerland can be explained almost exclusively by industrial activity. The positional changes are presented comprehensively on the Technology Outlook website, but not in the management summary's four-quadrant diagram.

SATW has been following Swiss universities' discussions on Twitter (rebranded as X in 2023) since 2018. Averaged across 2021 and 2022, the dominant discussion topic was photovoltaics: 33 percent of all universities tweeted on photovoltaics, 31 percent on blockchain, 29 percent on extended reality, 18 percent on quantum computing and 16 percent on mass cultivation of stem cells. All technologies in the top five on Twitter show a shift to the right in the four-quadrant diagram. Over time, the number of universities tweeting about photovoltaics and quantum computing has risen, with the increase being particularly pronounced for photovoltaics. The number of universities tweeting about the other three of the top five technologies discussed on Twitter has declined. A transfer to industry seems to be imminent here, as the shift to the right in the four-quadrant diagram also suggests.

# Four-quadrant diagram

## Technological niches

Return on investment must be assessed. It is necessary to improve international marketing, open up new markets and optimise manufacturing processes in order to reduce production costs.



**Artificial photosynthesis** uses solar energy to split water into oxygen and hydrogen, then convert these into hydrocarbons and fuels using CO<sub>2</sub> from the atmosphere or from industrial exhaust gases. This procedure is likely to make an important contribution to a sustainable energy supply.

## Technological stars

The opportunities for positive future development are good and should be exploited. In order to keep up with the times, companies must harness this knowledge and open up new markets.

• **Photovoltaics**

**Alternative protein sources:** The meat industry has a huge environmental impact. For this reason, consumers are seeking alternatives to meat products. However, developing them only makes ecological sense if the relevant players tackle the big issues together. It pays off: In 2021, Swiss firms in this sector generated sales revenue of around 500 million Swiss francs worldwide.



• **Mass cultivation of stem cells**

• **Alternative protein sources**

• **Sustainable food production**

• **5G**

• **Artificial photosynthesis**

• **Carbon capture and storage**

• **Blockchain**

• **Bioinspiration and biointegration**

## Technological hopefuls

The market is not ready yet. Time will tell whether these are rising stars or dead wood. Developments should be monitored and the international market potential determined.

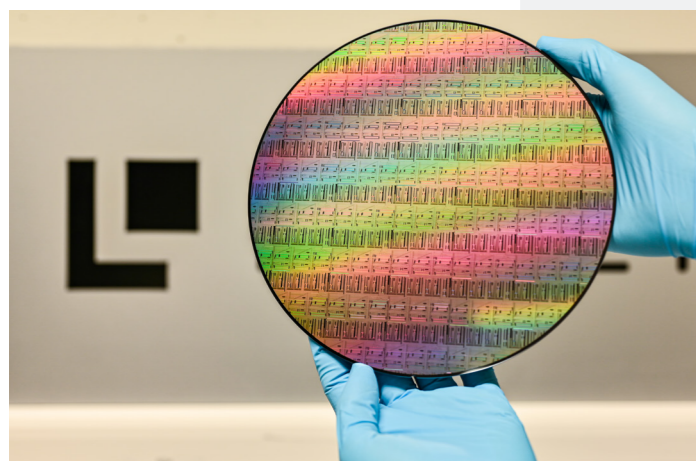
• **Extended reality**

## Technological surefire successes

The technologies in question are only developing slowly at present. Further developments should be closely monitored. Investment in education, training and research could pay off.

• **Internet of Things**

• **Connected machines**



**Photonic integrated circuits (PICs):** Laser diodes and filters instead of transistors and resistors: Chips with photonic circuits are more energy-efficient than their electronic predecessors. This technology is considered groundbreaking in the light of the high electricity consumption of future IT infrastructure and it offers market opportunities for specialised firms.

Research competence in Switzerland

• **Quantum computing**

• **Quantum and post-quantum cryptography**

• **Personalised nutrition**

• **Autonomous vehicles**

• **Geothermal energy**



**Biocatalysis** relies on micro-organisms to accelerate reactions and is a valuable alternative to chemical synthesis: It increases the efficiency and specificity of processes. Against the backdrop of energy shortages and climate change, it holds out the prospect of greener chemistry and a comprehensive circular economy.

• **Bioplastics** • **Thermal interface materials**

• **Fibre-optic sensors** • **Antimicrobial surfaces**

• **Robotic surgery** • **PICs** • **Microbiome**

• **Digital twin**

• **Biocatalysis** • **Synthetic biology** • **Mobility concepts**

• **Low-carbon concrete**

• **Sustainable adhesives and sealants**

# International trends

Since 2018, SATW has been monitoring the official accounts of 833 universities in Switzerland, Germany, France, Italy, Austria and the UK on Twitter (rebranded as X in 2023). This kind of analysis shows how the universities perceive the technological discourse in their respective societal environments, and permits inferences about which topics receive attention where and when. However, it is not possible to infer what is being researched where, or how intensively.

In the five years from 2018 to 2022, the monitored universities' Twitter accounts posted around 1.7 million tweets. Around 17,000 of these referred to technologies described in Technology Outlook. The two research categories 'digital world' and 'energy and environment' are particularly noteworthy. Both of these attracted far more attention across Europe than the research categories 'manufacturing processes and materials' and 'life sciences'.

The research category 'digital world' attracted less attention in all countries. This downturn was especially marked in Switzerland and the UK. In particular, the universities tweeted less about the technologies that had attracted most attention in the preceding years: blockchain (-9 percentage points), Internet of Things (-8 percentage points) and extended reality (-6 percentage points) – still among the most present technologies, despite the decline. Digital twins (+4 percentage points) and quantum computing (+2 percentage points) were technologies that saw positive development.

Attention paid to technologies in the 'energy and environment' category increased everywhere except in Italy. This positive development was driven by photovoltaics (+4 percentage points) and negative emissions technologies (+2 percentage points) in particular. Interest in photovoltaics rose more sharply in Switzerland (+16 percentage points) than anywhere else in Europe. In contrast, mobility concepts received less attention almost everywhere.

# Opportunities for Switzerland

New technologies draw particular attention if they are better than existing ones: higher efficiency, improved safety or more effective environmental protection. Thus, they generally have an impact on multiple domains and require interdisciplinary thinking.

As a location for research and business, Switzerland thrives on ecosystems in which players from different research fields and industrial sectors come together, and is predestined for interdisciplinary approaches to solution-finding. According to the participating experts from the worlds of research and industry, the following technologies in Technology Outlook are among those that represent a major opportunity for Switzerland, due to their interdisciplinary requirements: *bioinspiration and biointegration, connected machines, microbiome, personalised nutrition, synthetic biology*.

Interdisciplinary research fields have disruptive potential, but face funding difficulties. In order to assess the technically complex requests for financial support, interdisciplinary evaluation committees are essential.

Specialised high-tech and niche applications, such as *anti-microbial surfaces, bioplastics, digital twins, photovoltaics and photonic integrated circuits (PICs)*, offer great potential for Switzerland as a business location.

These technologies and the resulting applications can be developed by established firms of all sizes, but also by start-ups. In addition, there are opportunities for interesting business cases. This generates jobs and added value in Switzerland.

There are some technologies in which Switzerland can play a pioneering role by exporting know-how instead of products. It can serve as a living lab in the development process and a conduit for channelling findings into further development. *Low-carbon concrete, mobility concepts, carbon capture and storage, and personalised nutrition* are particularly relevant in this context.

For Switzerland to flourish as a business location, it is very important that research and industry be closely interlinked. This can only happen if there is a regular exchange between the centre of knowledge and the centre of industry, and if applied research is funded.

# Showcases



Personalised machine translation from Textshuttle



## One company – one voice

Would you go on a challenging mountain hike with a dog you don't know? The answer to that is probably quite simple. It is the same with translations of company texts. Who wants to entrust them to freely available software like ChatGPT, Google Translate or DeepL, which does not know the firm's terminology or language style? Textshuttle, a University of Zurich spin-off, develops software that is based on machine learning, much like the freely available tools, but is also trained to

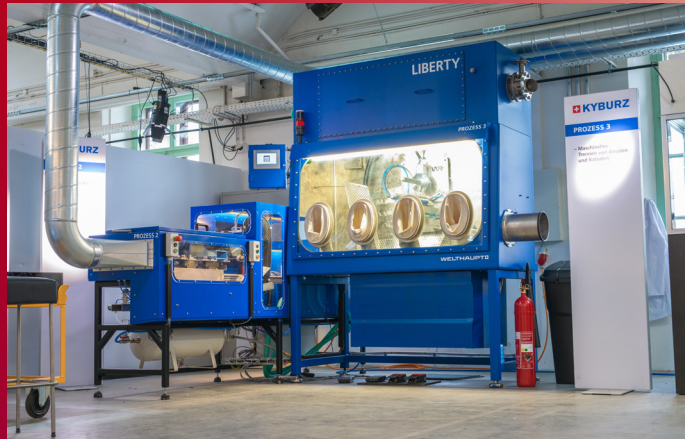


*“Textshuttle gives every business its own voice.”*

**Samuel Läubli**, Textshuttle

use a company's in-house phrases and linguistic rules. The software absorbs a company's language style guide, so to speak, and also learns the phraseology of professional translators. This is also what makes such an application so beneficial: Solutions adapted to firms deliver translations of

higher quality than comparable free tools and lead to a 40–60 percent increase in the efficiency of language services. In addition, the data remains with the customers themselves or on servers in Switzerland. This means that sensitive information can also be machine-translated.



Equipment developed by Kyburz for mechanically cutting open battery cells and removing the electrodes for recycling



## Recycling batteries in a water bath

How can the rare resources in batteries be recovered in an environmentally friendly way? This question is what started the development of a novel recycling process at Kyburz. This firm is known for the three-wheeled electric delivery vehicles used by Swiss Post. Maximum use is made of these vehicles'



*“We don't regard old batteries as waste, but as a resource.”*

**Olivier Groux**,  
Kyburz Switzerland AG

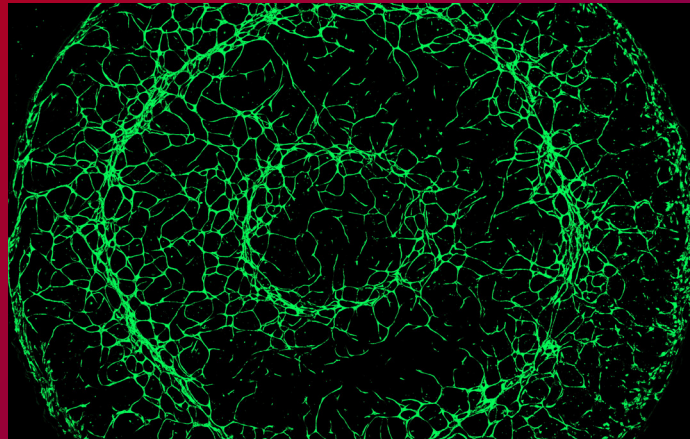
resources, in a cycle. Batteries that are no longer suitable for reuse go through a two-stage recycling process: Once the battery cells have been discharged, they are mechanically cut open and their electrodes are removed. Next, water is used to separate these into their constituent elements. The active material, which contains the resource

lithium, is thus recovered. Last year, it was demonstrated that new battery cells can be made from the recycled material. Compared to conventional battery recycling, this new procedure has the advantage that it does not require chemicals and consumes little energy. It facilitates sustainable recovery of battery resources and helps to address an acute problem associated with electromobility.

# Showcases



Sample element of a lattice structure made from shape-memory steel



Sound-induced tissue organisation

 Empa

## Earthquake protection in four dimensions

Pairs of glasses made from shape-memory alloys revert to their old shape when placed in hot water: a property that also has potential when it comes to supporting and stabilising buildings. This requires iron-based products – reinforcing rods with shape-memory properties. Researchers at Empa have devel-



*“If scaling up is successful, 4D-printed lattices could be used to secure architectural structures against earthquakes.”*

Irene Ferretto, Empa

oped a new type of iron alloy. Its memory effect is triggered at temperatures that cannot even be reached by sunshine, but are still not high enough to damage the concrete. Reinforcing rods with optimal properties are being printed using this new kind of shape-memory steel. Combining material that has a memory effect with 3D printing leads to 4D printing, or printing in four

dimensions. For buildings though, the full potential of this procedure is only achieved when complex structures are printed, such as lattices with memory properties. Such a lattice could, for example, absorb the shock waves of an earthquake and subsequently be reset to its original state by applying heat. And not just once, but again and again.

 MimiX Biotherapeutics

## Implants from the loudspeaker

Tissue organisation via sound is the idea that led to the founding of MimiX Biotherapeutics. Cells are exposed to sound in a hydrogel, a network swollen with water. As soon as the desired geometry has formed with the aid of music, they are fixed in place. The resulting implant is a three-dimensional piece of artificially produced tissue with a defined spatial arrangement of cells. Studies in mice show that the implants serve as germ



*“The procedure is so simple that the aim is to produce the implants by patients’ hospital beds.”*

Tiziano Serra,  
Mimix Biotherapeutics

cells for physiological structures: They organise diseased tissue in their surroundings and form vessel-like structures that are essential for healing. In addition, the implants are well tolerated by the body. They are thus predestined for applications in regenerative medicine and could become a game-changer in bone or skin regeneration, as well as in the development of artificial mini-organs. The procedure

is well tolerated by the cells and technically simple. The possible applications are not limited to medicine though: This technology could also aid the production of laboratory-grown meat. Imitating nature to orchestrate life.