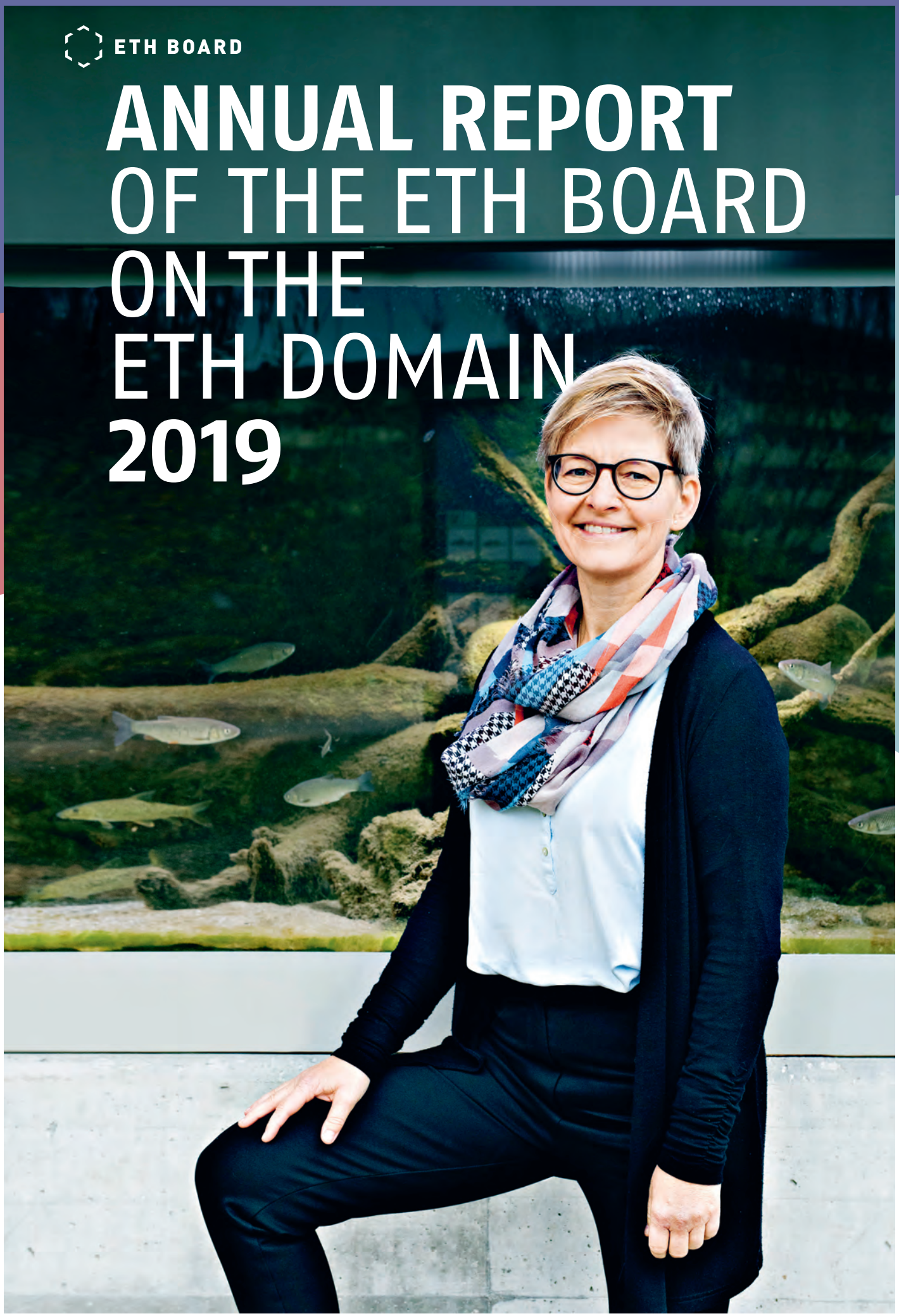
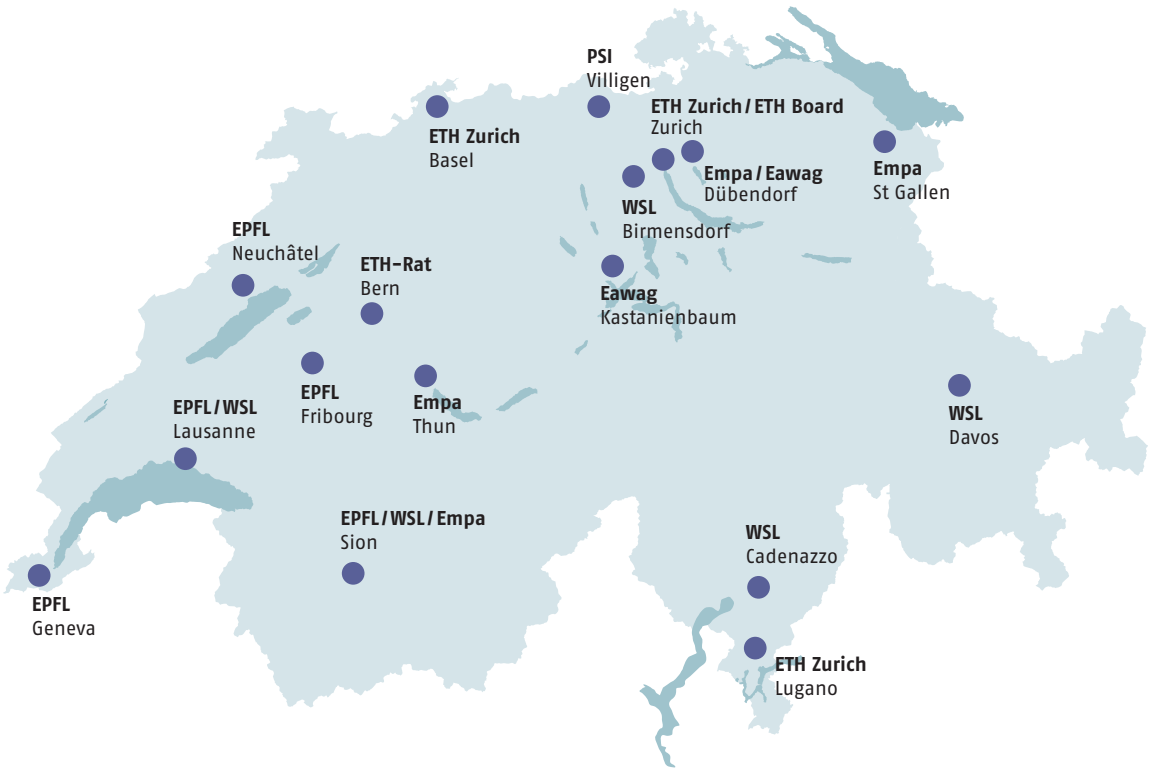
ETH BOARD

ANNUAL REPORT OF THE ETH BOARD ON THE ETH DOMAIN 2019



VISION

The ETH Domain strives to strengthen the competitiveness of Switzerland in the long term and contributes to the development of society through excellence in research, teaching and knowledge and technology transfer. It endeavours to serve as an exemplary beacon by assuming its share of responsibility for the management of urgent social challenges, the enhancement of the quality of life, and the long-term maintenance of our natural resources.



The ETH Domain and its institutions
Higher education, research and innovation of the highest standard: the ETH Domain provides these services with 22,600 employees, more than 33,600 students and doctoral students and a pool of around 860 professors.

The ETH Domain consists of the two Swiss Federal Institutes of Technology ETH Zurich and EPFL as well as the four federal research institutes: the PSI, WSL, Empa and Eawag. The strategic leadership and supervisory body of the ETH Domain is the ETH Board.
www.ethdomain.ch I www.ethboard.ch

ETH Domain

FACTS & FIGURES

ETH BOARD

The ETH Domain consists of the two Swiss Federal Institutes of Technology ETH Zurich and EPFL as well as the four federal research institutions, the Paul Scherrer Institute (PSI), WSL, Empa and Eawag. Appointed by the Federal Council, the ETH Board is the strategic governing and supervisory body of the ETH Domain.

www.ethboard.ch

The Institutions of the ETH Domain

ETH zürich

At ETH Zurich, approx. 500 professors educate around 22,200 students and doctoral students from over 120 countries. Together they are engaged in research in the fields of natural science, engineering, architecture, mathematics, system-oriented sciences, as well as in management studies and the social sciences. This knowledge flows into industries of the future such as cleantech, medtech or cyber security and forms the basis for around two dozen new ETH spin-offs every year. Graduates on the degree courses and continuing education courses use the knowledge they acquire at ETH Zurich to ensure that Swiss companies can compete globally.

www.ethz.ch

EPFL

EPFL is one of the most international of all European technical universities. It hosts over 11,400 undergraduate students and doctoral students from over 120 countries. It has more than 370 laboratories conducting leading research in areas such as renewable energy, medical technology, neurotechnologies, materials science and computer science. EPFL produced a new start-up every other week in 2018. To mark its 50th anniversary in 2019, EPFL redesigned its image and unveiled its new logo. There were various events held throughout the year, including the "Open Days", which attracted 40,000 visitors.

www.epfl.ch

PAUL SCHERRER INSTITUT PSI

The Paul Scherrer Institute (PSI) develops, builds and operates large-scale and complex research facilities, which it makes available for use by the national and international research community. All of these large-scale research facilities are unique in Switzerland, and in some cases the PSI is the only place in the world to have them. The institute's own research focuses on the fields of matter and materials, energy and the environment, as well as humanity and health.

www.psi.ch

WSL Swiss Federal Institute for Forest, Snow and Landscape Research WSL

WSL investigates changes to the terrestrial environment, and the use and protection of natural habitats and cultural landscapes. It monitors the condition and progress of forests, landscape, biodiversity, natural hazards and snow and ice, and develops sustainable solutions for socially relevant problems. WSL also includes the WSL Institute for Snow and Avalanche Research SLF Davos.

www.wsl.ch

Empa Materials Science and Technology

Empa is the interdisciplinary research institute of the "ETH Domain" for materials science and technology. On the basis of its research, it develops solutions to meet the biggest challenges currently facing industry and society, and therefore plays a significant role in reinforcing the innovative capacity and competitiveness of Swiss industry in an increasing competitive environment.

www.empa.ch

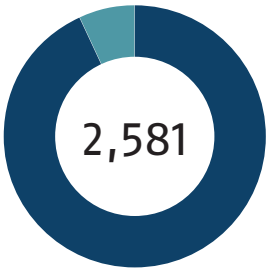
eawag aquatic research

Eawag is one of the world's leading water research institutes. Its strength and success are based on the combination of research, teaching and continuing education that it has provided for over 80 years, along with consultancy and the transfer of knowledge. The combination of natural sciences, engineering and social sciences enables comprehensive research into water in relatively untouched rivers and lakes, right through to waste water management systems.

www.eawag.ch

Total federal contribution[1]

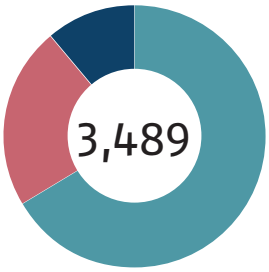
CHF millions



Federal financial contribution	2,373
Investment credit for ETH Domain constructions	208

Expenses

CHF millions



Personnel	65.5%
Other current expenditure	20.9%
Investments	13.6%

Personnel

Employment contracts

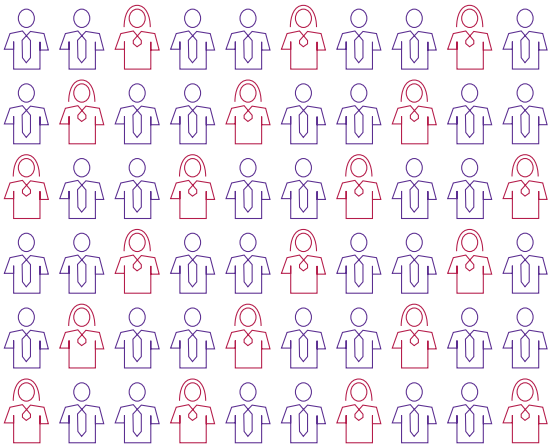
22,599

Proportion of women: 35.1%, apprentices: 458

Students and doctoral students

33,642

Proportion of women: 31.7%



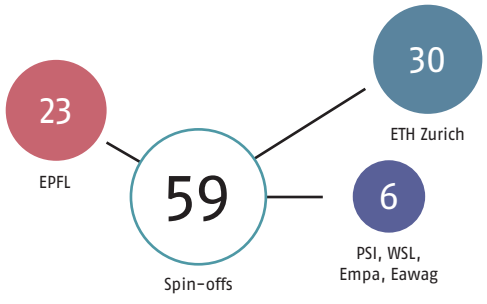
Professor appointments

University rankings

THE World Ranking	THE Europe Ranking	QS World Ranking	QS Europe Ranking
13	4	6	2
38	10	18	6

ETH Zurich EPFL

Spin-offs from the ETH Domain



[1] Credits taking into account the expenditure ceiling
[2] Nominations of new professors, see p. 45

Annual Report of the ETH Board on the ETH Domain 2019

Financial Report:
www.ethboard.ch/financialreport2019

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PSI: Biomedical research

Top of the world

The SwissFEL, the PSI's latest large-scale research facility, features sophisticated X-ray laser technology as well as refined sensor technology. In addition to materials science, environmental and energy research, life sciences in particular will benefit from the new possibilities offered by the 750 metre-long facility.

Empa: Power-to-X

"We don't have an energy problem, we do have a CO_2 problem"

As head of the Automotive Powertrain Technologies laboratory, Christian Bach with his team are looking for ways to convert road traffic from currently being based almost entirely on fossil fuels to renewable energy in the future.

WSL: Environmental data portal

Accelerating research

How do you make valuable environmental data more accessible? The WSL is mounting a data offensive and setting up a platform called EnviDat.

Eawag: Alternatives to animal trials

Excellent alternatives

Toxicity tests are mainly carried out on livestock. Within the context of environmental risk assessment, this is done most commonly on fish. An alternative method developed by Eawag researchers is currently overcoming crucial hurdles to its widespread use in practice.

FOREWORD

Beth Krasna,
President
of the ETH Board

Beth Krasna was Acting President of the ETH Board from May 2019 to January 2020 after the previous President Fritz Schiesser retired at the end of April, having reached retirement age. In February 2020 Michael O. Hengartner took over the presidency. Krasna has been a member of the ETH Board since 2003 and President of the Audit Committee from 2008 to 2019. Since February 2020, Krasna has again been Vice President of the ETH Board.

Dear readers

Klimajugend – Climate youth has been chosen as word of the year for 2019 in the German-speaking region of Switzerland. The French-speaking cantons call it *vague verte*, and the Italian-speaking part of the country refers to an *onda verde*. They all refer to the same issues of climate change and sustainability, issues which the ETH Domain takes seriously. For example, more than half of the 350 laboratories at EPFL are engaged in research on the UN's Sustainable Development Goals. With its competence centres on nutrition, climate change and urban development, ETH Zurich is a world leader in teaching and research on sustainable development. The research institutions of the ETH Domain are making significant contributions towards the sustainable restructuring of the Swiss energy system. They play a central role in practical research and knowledge transfer in the area of the environment.

The ETH Domain is also a beacon institution in construction and operation. It has further reduced environmental pollution in recent years, and its energy efficiency has increased by more than a third since 2006.

In 2019, the two Federal Institutes of Technology either achieved good grades in most relevant international university rankings or maintained their very good rankings. They continue to be among the best universities in the world. The external evaluation of the ETH Domain, which is performed every four years, also highlighted the exceptional quality of the two universities and the four research institutes. The ETH Domain also celebrated an anniversary in 2019 as EPFL turned 50. The one-time *Ecole Polytechnique de l'Université de Lausanne* has grown into a world-class university, which has made a major contribution to making the French-speaking part of Switzerland a thriving region.

The two Federal Institutes of Technology and the four research institutes are committed to working together to find solutions to the many challenges facing our society. The impact of climate change is paramount. Consequently, the ETH Board would like to focus research in the ETH Domain more specifically on this issue. The ETH Board took the landmark strategic decision in September 2019 to establish a research institute for environment and sustainability and to pool the strengths of WSL and Eawag in the medium term. The ETH Board feels sure that this will boost scientific competence, cooperation within and outside the ETH Domain, as well as the quick transfer of knowledge further. The new research institute will also help to ensure that the ETH Domain remains well positioned in the future and can hold its own in the face of international competition – in the interests of the Swiss economy and society.

Zurich / Bern, January 2020

Beth Krasna, President of the ETH Board

ETH Domain

EXCELLENT RESEARCH FOR THE CHALLENGES OF OUR AGE

With its high standard of teaching and research, the ETH Domain also has a great responsibility in addressing current challenges. It is focusing on issues such as climate change, the sustainable use of resources or the digital transformation. A reliable education policy framework, as well as effective structures, are crucial factors in meeting this responsibility.

Interim evaluation of the ETH Domain in 2019: outstanding quality, unique positioning and a key hub for innovation.

"Exceptional quality", "unique positioning", "important innovation hub" – the international group of experts of the 2019 intermediate evaluation emphasised the great performance and central importance of the ETH Domain both within the Swiss university landscape and in comparison with teaching and research institutions worldwide. The intermediate evaluation of the ETH Domain, which was commissioned by the Federal Department of Economic Affairs, Education and Research (EAER) and carried out in the middle of the current ERI period, is testament to the excellent work being done at the six institutions. The two Federal Institutes of Technology are among the top universities in the world. This is also evidenced by the various international rankings in which the two universities were very well placed in 2019 once again (see Fig. 16 and 17, p. 93).

Spotlight on research:
Sustainable development and digitalisation

With their excellent research and teaching, the institutions of the ETH Domain can play an important part in addressing current and future challenges facing our country. During the meetings for the development of the ERI Dispatch 2021–2024, some of these challenges were identified as central "approaches" for all ERI funding areas. For example, they include sustainable development and digital transformation. Both areas are also priority areas of research in the ETH Domain.

In the broad subject area of sustainable development, the institutions have a particular focus on energy research. The "Coordinated Energy Research Switzerland" action plan as a package of measures for the Federal Government's 2050 Energy Strategy has an important role to play here. Furthermore, energy research is one of the four strategic focus areas defined by the ETH Board in the current ERI period. Challenging tasks such as the sustainable

Art or architecture? With a new type of digital 3D printing process of concrete developped by ETH Zurich allows to implement an infinite number of design possibilities, such as for the "Concrete Choreography" columns of the Origen Festival in Riom. dbt.arch.ethz.ch

› Andreas Eggenberger / ETH Zurich

restructuring of Swiss energy production, lowering CO_2 emissions or increasing the efficiency of the energy system are being addressed in a large number of research projects. The energy research platform ReMaP (Renewable Management and Real-Time Control Platform) was launched in 2019. This platform is dedicated to interconnected issues, such as changing electricity consumption in the case of local energy storage. Existing research and technology transfer platforms in the ETH Domain are being connected, opening up links between the distribution network, energy management, buildings and mobility. The institutions of the ETH Domain have also been involved in the development of SWEET (Swiss Energy Research for Energy Transition), the successor programme by the Swiss Federal Office of Energy (SFOE) to the "Coordinated Energy Research Switzerland" action plan.

As far as digital transformation is concerned, the institutions of the ETH Domain are conducting intensive research into the technological foundations and applying them in a wide range of areas. All three strategic focus areas of the ETH Domain "Personalized Health", "Data Sciences" and "Advanced Manufacturing" contain central aspects of the digitalisation process. The two Federal Institutes of Technology have been enhancing their capacities for some time now, particularly in the areas of computer sciences and information and communication technology. This includes the seven additional professorships which ETH Zurich and EPFL are setting up as part of the Federal Government's "Digitalisation" action plan. Five of those places were filled in 2019. One of the priorities is the security challenge in the digital environment. The two Federal Institutes of Technology successfully launched the joint Master's programme Cyber Security in 2019. In addition, parts of the Cyber-Defence Campus of the Federal Department of Defence, Civil Protection and Sport (DDPS) were opened at EPFL and ETH Zurich in the autumn. The purpose of the campus is to provide early warning of rapid developments in cyber security and to work on new technologies for hazard prevention.

50

students were enrolled on the new joint Master's programme Cyber Security at both Federal Institutes of Technology in the 2019 autumn semester.

WEF 2020
Exciting panel discussion about the digital change in Switzerland. Empa Director Gian-Luca Bona, ETH Professor Stefanie Hellweg, moderator Patricia Laeri and Peter Terwiesch, ABB (from left to right).
› Andreas Eggenberger/ ETH Zurich

CEO Lorenz Meier, former scientific WSL staff member, presents Federal Councillor Parmelin Geopraevent, which is active in the field of monitoring and alerting natural hazards.
geopraevent.ch
› Markus Mallaun/ ETH Board

In dialogue with policy-makers and society
In the face of current developments and challenges, responsible scientific research involves acting as an advisor to policy-makers in order to facilitate decision-making based on facts. Trust in science and its processes is of the utmost importance, especially in the current context of fake news and highly personalised and polarising debates. The need for science to be "given a face" and for experts from the ETH Domain to have advisory input in the political negotiation process is stressed in the final report of the intermediate evaluation.

The social responsibility of the scientific community is particularly evident in the area of digital transformation. The continuously expanded range of continuing education courses offered by the institutions of the ETH Domain, adapted to reflect the current needs of the various professions, is designed to help get society ready for the digital age. The education of the younger generation is of particular importance. For example, the two Federal Institutes of Technology support the development of ICT teaching in schools with initial and further training courses for teachers and the development of curricula.

Reliable framework conditions, effective structures
Various factors are of pivotal importance in order to continue to provide excellent research and teaching for current challenges in the future. The experts who contributed to the intermediate evaluation have touched upon several important framework conditions in their recommendations. One of them is stable, reliable funding by the Federal Government. The autonomy of the ETH Domain and its six institutions in the use of financial resources is also key in this context. This also applies to the free, strategic reserves that give the institutions room for manoeuvre in favour of new scientific fields and initiatives. The new guidelines for the reserve policy in the ETH Domain passed by the ETH Board set out reference values and principles for management, among other things. The expert panel also emphasised the international openness of the ETH Domain as another important framework condition. Access to cross-border research development programmes such as "Horizon Europe" is central to the attractiveness and international network of Switzerland as a centre of research.

In addition to the external framework conditions, the intermediate evaluation also looked at how the structure of the ETH Domain has evolved historically. The experts recommended continuing the review of this structure that had been initiated by the ETH Board in order to increase the agility and flexibility of the ETH Domain and to gear its development towards future needs. In September, the ETH Board took the key strategic decision to merge WSL and Eawag in the medium term into a research institute for the environment and sustainability with international stature. At the end of 2019, the consultation of the institutions of the ETH Domain on this project got under way. This is intended to enable research in the ETH Domain to make an even more purposeful contribution towards solutions for a sustainable future for our society and to further boost Switzerland's position as a centre of research in the environment and sustainability.

FASCINATION ETH DOMAIN

ETH Domain

KNOWLEDGE THAT WORKS FOR EVERYONE

How can the whole population benefit from technical and scientific advances made in the ETH Domain? This is illustrated by a number of examples from various fields – and a look back to the 19th century, when engineers brought their expertise to civilian society.

A success story: over a period of more than 30 years, over 7,000 patients have received treatment, more than at any other proton therapy facility in the world. psi.ch/de/protontherapy

Homo faber is something of a Swiss national hero. One of the few engineers to have achieved fame in world literature. Damien C. Weber, head of proton therapy at the PSI, has another hero. "Have you ever heard of Robert Wilson? He wasn't just a physicist, he was also an artist and a great humanist." The pioneer in proton therapy for cancer was the founding director of the American ring accelerator, Fermilab. He dedicated his career to classical fundamental research. Others took on the task of proving his assumption in 1947 that protons should be particularly well suited to the precision, localised treatment of tumours. The proof arrived in 1954 with the first treatment.

Today, 65 years later, we are sitting in a rather mundane meeting room in the middle of the PSI campus. But when Weber talks about Wilson, you can hear the doctor's passion in every word he says. He doesn't just see the possibilities of his high-tech equipment, he sees the benefits for his patients in particular. Children also come here, often from great distances, because the qualities of proton therapy are best demonstrated in bodies that are still growing: the proton beam only takes effect inside the body when the protons have lost speed. This means more intensive radiation at the site where the tumour is to be treated and less radiation in the healthy tissue that needs to be protected. This can be crucial for successful recovery. At the PSI, patients are treated with the best proton therapy available worldwide – and it's hardly any wonder seeing as the spot-scanning technique was developed here. And true to their task, physicists, doctors and engineers at the PSI have been conducting continuous research into the use of innovative treatment concepts.

Engineers possess the expertise, although in the early days of engineering, it was almost exclusively for military purposes. It was not until the 19th century that engineers broke away from this role, and civil engineering took shape. It became all about technical and economic progress that worked for everyone. However, military research continues to be the driving force behind many technologies – such as GPS – which also benefit civil society. Meanwhile, the engineers set out to "rationalise" land use, surveying it and covering it with all manner of infrastructure. Nature was largely tamed, and a great deal of practical knowledge came together, especially in Switzerland. "We have carried this knowledge over into the computer age," says Perry Bartelt, who is in charge of the RAMMS simulation software at the WSL Institute for Snow and Avalanche Research SLF in Davos. "What's happening on the mountain?" is a question people have asked since the dawn of time. Thanks to a wealth of experience and complex models, there is now often a scientific answer to hand. Avalanches and debris flows can be calculated in the computer and traced in detail on a digital map. Bartelt regards RAMMS specifically as a service to society. The software is a great success, both in Switzerland and further afield. This success could not be measured primarily in terms of much-cited academic articles,

The DFAB House in the NEST modular research and innovation building on the Empa campus is the largest house in the world created using digital fabrication.
› Roman Keller

A great success, both in Switzerland and further afield: thanks to the SLF's RAMMS software, avalanches and debris flows can be calculated by computer.
ramms.slf.ch

but rather through contact with practical application. The close cooperation with engineering offices, in particular, was extremely important: "This was the goal: we wanted to provide the planners with a tool that would enable them to gauge which construction measures would be useful and where." The simulation is improved continuously through feedback from practical experience and in-house field research.

But at times there is a sense that engineers have lost this sense of responsibility towards society as a whole. "Move fast and break things"? The infamous slogan from the early days of Facebook probably still describes the basic attitude of many digital pioneers who have found that success can follow mistakes. Marcel Salathé, biotechnologist and specialist in digital approaches in life sciences, wants to help shape this world from a non-commercial perspective. Why shouldn't digital know-how, which is obviously available at technical universities, be made available to wider society? The EPFL Extension School has been offering online courses on digital skills for about two years now. It's a kind of community college for civil engineering in the 21st century. Since the relevant infrastructure in many jobs is digital nowadays, you have to be able to program websites or analyse and visualise data sets. While the interest is there, the EPFL label is also a "double-edged sword". Much of the general public was not attracted by the offer, saying that it is not for everyone. For this reason, Salathé is planning a communication offensive: why not run a poster campaign in major Swiss railway stations? And why not expand the model even further, for the next generation? The latest idea from the enterprising EPFL professor is to offer a free module on artificial intelligence for schoolchildren.

EPFL Extension School – Europe's leading school for e-learning. Whatever your age, education or digital skills, you can acquire valuable skills for the digital transformation.
extensionschool.ch

But back to the engineers and planners who design our analogue environment. How do you build a world that is increasingly aware of its fragility and limitations? And in which a "civilian" society, whatever that may mean, does not simply stop at national borders; another important difference to the 19th century. Matthias Kohler, in a team with Fabio Gramazio, Professor of Architecture and Digital Fabrication at ETH Zurich, stressed in an interview that the team's primary concern was not to try out new forms of construction (he calls it the "liberation of concrete"). Ultimately, it is always about sustainability. Kohler hopes that this will be understood not only ecologically, but also from a social perspective. Apart from making better use of resources, he also wants to bring a certain "sensuality" back into architecture, as a contrast to the "fully rationalised building" that he sees as an expression of industrial building. However, a "tailor-made version of industrialisation" is being developed using digital methodologies. You can get a sense of this on the way to Kohler's office on the ETH Hönggerberg campus: on the ground floor, large industrial robots work in the world's largest laboratory for robotic fabrication in architecture, and the upper floors, where teaching is also carried out, are full of designs with unfamiliar

use of forms. Research and experiments are not the only things that go on here; research findings are also put into practice. One result is on display at the Eawag-Empa campus in Dübendorf; the modular research and innovation building NEST (Next Evolution in Sustainable Building Technologies), which is the only one of its kind in the world.

25%

lower energy consumption: the intelligent heating control system developed by the Empa Energy Hub is a NEST flagship project.

At NEST, pioneering building technologies can be tested in close collaboration with industry. NEST seeks to help these technologies through the difficult transition between the development laboratory and the market, says Enrico Marchesi, Innovation Manager NEST at Empa. The construction industry is one of the largest sectors in the economy, but unfortunately it is also the one with the most sluggish pace of innovation. Researchers who like simulations feel just as much at home in NEST as industrial partners who want to see how it works in practice, says Marchesi. It has developed into a flagship project in little more than three years since opening: it not only attracts great attention from national partners from research and industry, but is also regularly visited by international delegations. One of the flagship projects is an intelligent heating control system developed by the Empa Energy hub, which can reduce energy consumption by a good 25 percent. Its autonomous handling, just as importantly, is also widely accepted by residents. The most ambitious part of the NEST, however, is the DFAB House, the "largest house in the world created using digital fabrication" and the latest unit in which Gramazio Kohler Research, together with six other ETH professors, have taken their concept of digital design and construction to the ultimate level. Around 40 researchers from a variety of disciplines have been involved in planning the NCCR's "Digital Fabrication". Many parts, such as the unusual wooden façade timber framework, were even "generated" by algorithms. Kohler also believes that there has been a paradigm shift here planning processes are becoming adaptive, needs can be continuously coordinated. Building brings many voices together.

"In order to overcome the challenges facing us today, it takes the more wide-ranging perspective of an environmental scientist. Technological solutions alone will simply not be enough." This is something that Florian Altermatt is convinced of. As group leader at Eawag and Professor of Aquatic Ecology at the University of Zurich, he is investigating the state and changes in biodiversity in water bodies. In recent times "we have actually seen extreme changes, heavily influenced by land use". It would be the right time for a rigorous biodiversity assessment, with new techniques that he helped to develop such as environmental DNA (eDNA) analysis. At the same time, this knowledge is also of urgent social relevance: "We still have insufficient knowledge about biodiversity and we have important decisions to make." With one million species worldwide said to be in danger of extinction, in water or on land, Altermatt believes that a substantial change is needed, "and it cannot be of a technical nature alone". It won't be an easy task. He expects it to be nothing less than "one of the greatest challenges mankind has ever faced". But one which can be overcome with the right mix of expertise. At Eawag in particular, Altermatt sees a great deal of excellence in thinking about social conditions in interdisciplinary teams. Nowadays, theory and practice can no longer be separated. "As an ecologist, I conduct fundamental research, but the implementation of this systemic knowledge is extremely important to me and my colleagues." As a researcher, he is driven by theoretical insights. As an expert, he feels that he owes a duty of service to society; for example, he recently produced a synthesis report commissioned by the FOEN on how Swiss waters are being affected by climate change.

"As an ecologist, I conduct fundamental research, but as an expert, I owe a duty of service to society."

– Florian Altermatt, group leader at Eawag and Professor of Aquatic Ecology at UZH

ETH ZURICH

A SEISMOMETER FLIES TO MARS

What is the interior of Mars like? What is the structure and dynamics of the Red Planet? Planetary researchers only had a rough idea about this. They have only been able to use one of their most efficient methods of analysing ground vibrations for the past year or so, thanks to ETH Zurich.

Mars Seismological Service. The name conjures up a lot of images: a dome somewhere in the red dust, a pioneering project to explore and colonise the desert planet? It might sound like the stuff of science fiction, but it is real. Domenico Giardini, professor of seismology and geodynamics, would be happy to help on that. Three young researchers are sitting in front of a bank of screens in an office at ETH Zurich, analysing and characterising the data received. The Mars Seismological Service is operated in collaboration with seismologists from the Swiss Seismological Service. A number of groups at ETH Zurich are ultimately responsible for the data acquisition and control electronics. The highly sensitive electronics of the seismometer were developed at the Aerospace Electronics and Instruments Laboratory at ETH Zurich.

The analogy to the regular seismological service is no coincidence. There is a competitive edge to NASA's Discovery programs – whoever presents the best scientific idea is invited to join the flight. The proposal put forward by ETH Zurich went down well, and so the InSight mission brought the seismometer developed by the European consortium to the Red Planet. The proposal explicitly stated: "We will do everything in the Mars Seismological Service exactly as we do on Earth," said Giardini. This means using tried and tested infrastructure, existing knowledge and an institution with a reputation for a stable research environment.

"We will do everything in the Mars Seismological Service exactly as we do on Earth." Domenico Giardini from ETH Zurich relies on a proven infrastructure, existing knowledge and an institution with a reputation for a stable research environment.

But there is one difference. "The InSight instrument is more sensitive than any other instrument used on Earth." And it had to withstand a long voyage through space, not to mention a tricky landing. It was set down on the surface of Mars on 19 December 2018 as the only seismometer to detect vibrations. The first recording of a quake on Mars was made on 6 April 2019. The researchers use sophisticated methodologies to accurately pinpoint some of the one or two quakes that are recorded each day. To do this, Giardini and his team combine methods from the early days of seismology with modern analytical techniques. What they discover will not only help to answer unsolved questions about the geological structure of Mars, but more generally about the formation of Earth-like planets in the inner solar system.

"We already knew a lot about the surface of Mars," says Giardini, "but we could only speculate about the inner life of the planet." This is now being scrutinised for the first time with hard facts – a series of assumptions have been refuted. After just over half a year of InSight measurements, almost three quarters of the 2,000 or so models on the structure of Mars have already been discarded. And he adds with a smile: "There is quite a lot of discussion going on in the Mars research community right now. One thing is certain, quakes on Mars must have different triggers than those on Earth. They are mostly caused by shifts in the tectonic plates here, whereas Mars only consists of a single tectonic plate."

Because a completely new chapter has been started in planetary research, the InSight mission was a flight into the unknown. "We had no idea what kind of quakes to expect." So the scientists designed a broad amplitude spectrum. Giardini says that he would send up "much simpler sensors" next time. But there's one big problem that's hard to ignore – the wind on Mars. It has literally blown away all the seismographic measurement experiments on Mars up to now. And the InSight instrument also only transmits storm noise during the day on Mars. Things only calm down on the Red Planet at night. The seismometer listens all the more closely then.

Giardini knows that a mission like this can also go wrong. "You only get one chance. Everything has to work right as the mission is unmanned, and there is no astronaut on board to keep an eye on things." It takes a little bit of luck, too. ETH Zurich has specialists for the complicated data from smaller quakes, which are common on Mars, as has now been shown. But what they "hear" is also puzzling. The first seismic signals from the Mars quakes were easy for the researchers to classify, but the ensuing signals produced stronger echoes than expected. Some quakes lasted 10 to 20 minutes. In the meantime, many of our international colleagues are waiting impatiently for major tremors on the surface of Mars; such as a meteorite strike or a volcanic eruption. This would produce signals that would provide completely different insights into the structure of Mars. The Mars Seismological Service benefits them too.

Heidi clinches second place

The students from ARIS are thrilled to take second place in the Spaceport America Cup.
› Jérôme de Viraghi / ARIS

Students at the Academic Space Travel Initiative Switzerland (ARIS) had spent almost a year developing and building their rocket, "Heidi". The 30 students of ETH Zurich, Lucerne University and ZHAW School of Engineering competed against almost 40 other teams at the Spaceport America Cup in New Mexico in June. The aim of the competition was for the rocket to reach an altitude of 10,000 feet (3,048 metres) as accurately as possible and then to drop back to the ground with a parachute. Heidi's parachute was deployed at an altitude of 9,298 feet, and the Swiss rocket touched down gently. Only falling seven percent short of the target altitude, the ARIS team and Heidi soared to second place in the competition.

Honour for multiferroics pioneer

Nicola Spaldin, ETH Zurich Professor of Materials Theory, received the Swiss Marcel Benoist Science Prize for her research on multiferroics. This is a new class of materials that react to both magnetic and electric fields. This makes multiferroics promising materials for electronic components. As a young scientist, Spaldin investigated why multiferroics are so rare and how they can be produced. Thanks to her pioneering work, electronic devices with a new architecture and higher energy efficiency are conceivable in the future. Possible applications include ultra-fast computers, tiny data memories and precision measurements.

Pioneer in the field of multiferroics research: ETH Zurich professor Nicola Spaldin
› Daniel Rihs / 13 Photo

The first ETH Zurich unicorn is off to a gallop

The ETH Zurich spin-off GetYourGuide has reached an estimated value of over CHF 1 billion with a capital raising completed in May 2019. This makes the travel platform the first ETH Zurich spin-off to achieve the coveted unicorn status. The term unicorn is used by investors to describe start-ups that are so promising that their market value reaches one billion dollars even before the IPO. The unicorn club features other well-known names such as Uber, Snapchat and Airbnb. The GetYourGuide online platform was founded in 2009 by ETH Zurich doctoral students and has since developed into the world's leading provider of local day trips and travel activities.

The GetYourGuide online platform provides details of travel activities worldwide.
› GetYourGuide

The exchange between researchers and the visitors at Scientifica inspires both sides.
› Alessandro Della Bella / ETH Zurich

Inspired by research

When you see flags flying in Zurich with an eye on them, you know that Scientifica is taking place. Every two years, researchers from the UZH and ETH Zurich unveil their projects to the public over one weekend. In 2019, 25,000 visitors were once again struck by the infectious enthusiasm of over 400 researchers at exhibition stands, short lectures, science cafés and shows. Surveys (which are not representative) show that the dialogue works: 90 percent of the visitors described the researchers' statements as easy to grasp. By the same token, over 90 percent of the researchers rate the interest shown by the audience as high.

www.scientifica.ch

Turning light and air into petrol

The parabolic reflector on the roof of one of the ETH buildings marks a world first: the installation produces liquid fuel exclusively from sunlight and air. ETH Professor Aldo Steinfeld and his group have developed the technologies for this. The mini refinery filters CO_2 and water from the air, generates synthesis gas from it in the solar reactor and liquefies it to methanol. Other fuels such as kerosene or petrol are also possible. Fuel produced in this way is CO_2-neutral because only as much CO_2 is released during combustion as was extracted from the air during production.

www.prec.ethz.ch

Education summit on fostering talent

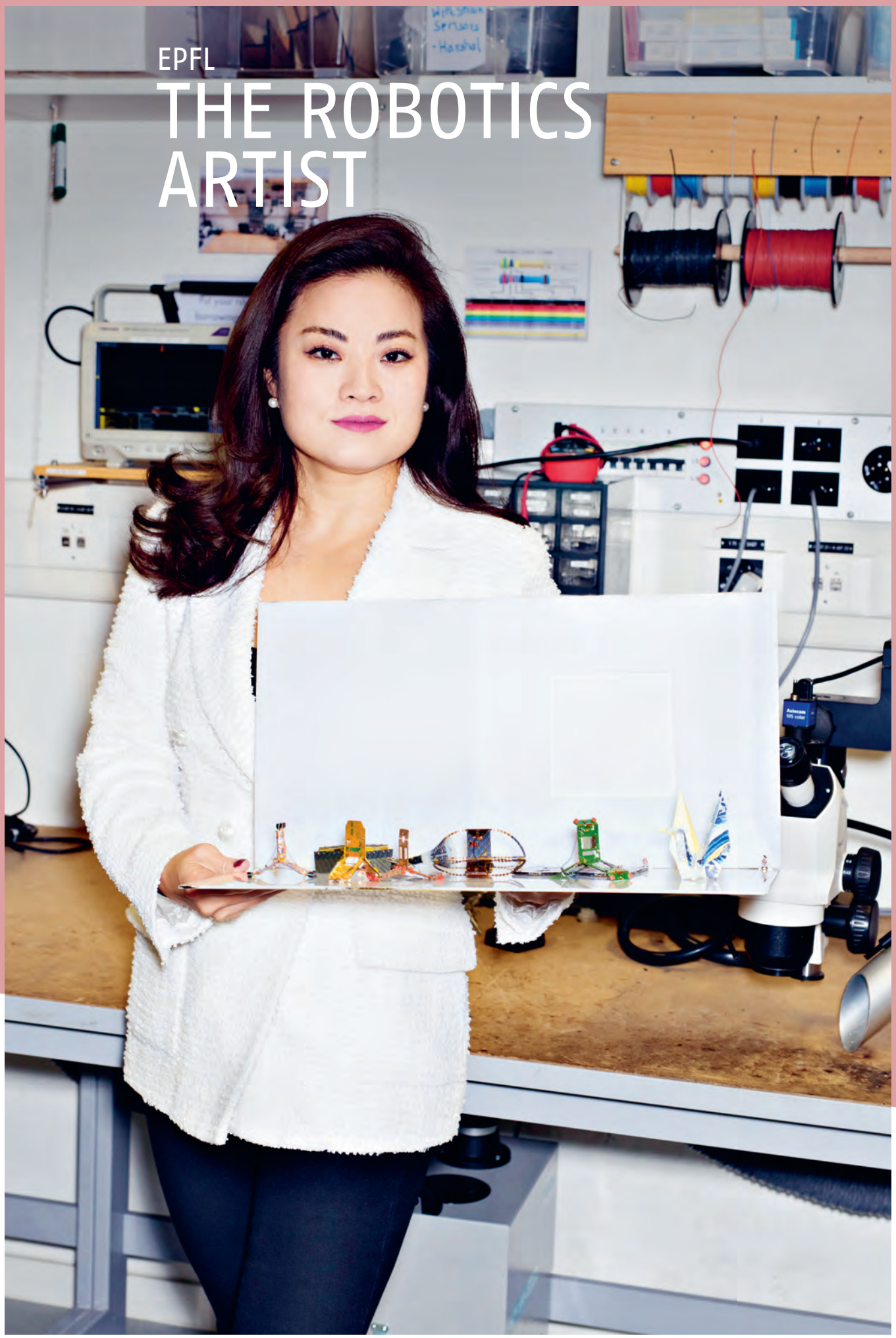
How is digitisation changing higher education and fostering talent? In September, more than 400 university leaders and leading educational decision-makers discussed this key aspect of higher education at ETH Zurich. These discussions were prompted by the World Academic Summit 2019 on "How talent thrives". ETH Zurich organised the event for the Times Higher Education (THE), which publishes the well-known World University Rankings. One conclusion was that digitalisation is changing the economy so rapidly that lifelong learning is becoming a key skill. The ETH Zurich representatives included President Joël Mesot, Rector Sarah Springman and Fields Medal Winner Alessio Figalli.

The mini refinery produces liquid fuel exclusively from sunlight and air.
› Alessandro Della Bella / ETH Zurich

The discussions of the THE World Academic Summit were presented visually.
› Andreas Eggenberger / ETH Zurich

EPFL

THE ROBOTICS ARTIST



Jamie Paik isn't your average robotics researcher, and the machines she and her team develop in the Reconfigurable Robotics Lab at EPFL are every bit as unusual. Are they conducting tests here for a future where machines will become such an intuitive part of our everyday lives as smartphones are today?

The word 'robotics' makes you think of little mechanical men or rotating metal arms, but certainly not of something like this: an unusual backpack with two pressure cylinders, tubes and rods, connected to bulging packages on the chest, back and sides of the wearer, an exosuit. The fact that Jamie Paik's colleagues are strapping the latest creation onto their own backs and testing it out reflects the image of a laboratory known for its experimental designs. What Paik and her team do in the Reconfigurable Robotics Lab at EPFL is perhaps something like an art department in the world of robot research. And that hardly comes as a surprise since Paik had once considered studying art. But then she moved into the field of technology. Then again, she has never had any fear of "going down unconventional routes".

She has consistently drawn her inspiration from unusual sources: one of her most successful designs originates from the odontomachus ant but bases its working principles on folding joints – a bit like origami. The tiny robots called Tribots can communicate with each other, act and create different motion sequences by reshaping themselves. These little helpers could potentially be used en masse for search and rescue operations. Some colleagues and industries would have found it difficult and rather "cute" in the early days – a veiled insult to Paik. She has always been concerned with very practical considerations, and the perception of the robot as being "cute" betrayed the limits of conventional robotics in her eyes. For a long time, this field had been bent on the idea of building ever more powerful, stronger, more high-precision machines. But it did not reflect its environment at all; robots slavishly followed command schemes – and they have become an ever greater danger for any people who get too close to them. We've all seen those pictures from the car-manufacturing industry: isolated production lines where robots do their monotonous work behind barriers and signs for "authorised personnel only".

Robotics artist and researcher Jamie Paik benefits from the possibility of freeform robotics in the Reconfigurable Robotics Lab.

Paik had a completely different "collaborative" idea about robots from the outset. As well as a different definition. She views a robot as an intelligent machine with the ability to provide feedback. The intelligence of this machine can be reflected on very different levels. It can be achieved in the possible movement options and not solely on the highly complex artificial intelligence. A decade has now passed since the origami robots were unveiled, and attitudes are gradually changing in the scientific community as well as in industry. The need for new intelligence and automation in the manufacturing industries, personalised technologies and health care have forced the field to open up to other forms and concepts of robots: adaptive and interactive human companions.

One of the examples is the soft exosuit, which serves to give active force feedback to the user via soft pneumatic actuators distributed over the upper body. The idea here is to support the body in its movements or to protect it against false movements with sufficient counter-pressure, for example during construction work. Paik's laboratory, the Reconfigurable Robotics Lab also maintains a stock of finer variants of these body-oriented machines; elastic skins with embedded pressure points that enable interaction via the sense of touch. This could finally make VR (virtual reality), a physical experience. Paik calls it TR; tangible reality. Is that still robotics in the narrower sense? Paik is not all that interested in that question; for her the ideal robot is invisible anyway, blending into our lives so effortlessly that we don't even notice it any more. Her work is chiefly driven by a desire to improve the quality of people's lives, especially for those with functional difficulties. In Paik's view, "today's technology is not really democratic". For that to change, there would have to be a suitably diverse team of people involved, from the concept, through development, to the final design.

She would give her machines a certain degree of autonomy, but in the end it would always have to be human beings who decided what to do. There would be only one instance in which she would design machines to be autonomous; for space exploration. For her, this is the ultimate challenge in robotics. And then she gets a little philosophical at the end of the chat. You never really know what you'll encounter in space. Adaptability is the decisive factor for survival there. Here on Earth, we humans are vastly superior to most artificial systems in this respect. But isn't that simply because evolution has taught us to claim that our intelligence, whether it be mental or intuitively physical, is a reflection of this environment? In space, it would be more of a level playing field. And adaptive robots, perhaps even swarms of them, could perform tasks which we humans are simply not equipped to do, optimised as we are for Earth.

The Bicycle Therapeutics spin-off on the Nasdaq

Bicycle Therapeutics is EPFL's third public spin-off. Backed by capital of 60.6 million dollars, it can continue its clinical trials for initial cancer treatment. Even though IPOs of European companies are very rare, the Lausanne campus can now boast three IPOs of companies based on technologies developed by EPFL researchers.

The spin-off develops drugs based on amino acid chains, called peptides, which bind to virtually any biological structure and can change their function. They act on the target tissue without destroying healthy cells. They can dock to a protein of a tumour cell and slow down its growth without damaging the surrounding tissue. The field of application for these therapies seems to be large: cancer, as well as respiratory and cardiovascular diseases, metabolic disorders, mental health problems and haemophilia. The Cambridge-based start-up uses know-how and a licence from EPFL.

bicycletherapeutics.com

An anti-ageing molecule

An anti-ageing molecule discovered in 2016 by Amazentis, a spin-off of EPFL and by school researchers, has cleared another hurdle on its way to becoming a commercial product. The benefits of urolithin A, whose precursor molecule is found in certain foods, have also attracted the interest of Nestlé Health Science. The global corporation recently signed a contract to integrate urolithin A into food supplements, food and beverages and health food products. The corporation holds an equity interest in Amazentis, which is headquartered in the EPFL Innovation Park. In addition, there are plans for a joint research programme to extend the molecule's field of application to the healthcare and medical sectors, in particular.

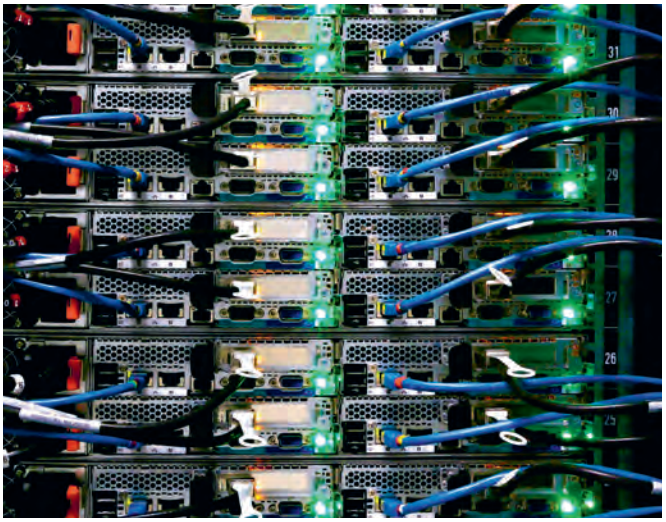
Extremely economical solar panels

The Insolight start-up's solar panels, which are standardised for series production, have a record efficiency of 29 percent for systems for the general public. The modules are based on tiny, high-performance cells on which the light is focused via lenses and offer a new approach in the field of solar energy. The start-up's panels promise greater profitability than conventional solar modules. "Our technology can reduce electricity costs by up to 30 percent on building roofs in sunny climates", explains Insolight CEO Laurent Coulot.

A precursor molecule of urolithin A can be found in pomegranates.
› Alain Herzog / EPFL

The three Insolight founders from left to right: Laurent Coulot, Florian Gerlich and Mathieu Ackermann.
› Alain Herzog/EPFL

Cyber Security: EPFL and ETH Zurich launch a joint Master's programme



› Alain Herzog / EPFL

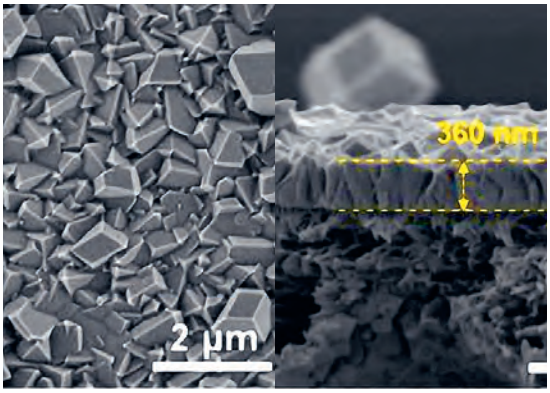
Data thefts, attacks on critical infrastructure systems, large-scale hacking: cyber security issues are a major concern in our increasingly networked society and there is a great need for professionals in this field. In order to promote education and research in the field of IT security, EPFL and ETH Zurich are pooling their expertise and, with the support of the Swiss government, are running a joint Master's in Cyber Security from the 2019/2020 academic year onwards. This course concentrates on the topics of cryptography, hardware, software and network security, as well as techniques for ensuring system security and gaining user confidence. The courses also cover the legal, ethical and economic challenges of an issue affecting all sectors of society.

Metal-organic framework compounds and carbon capture

EPFL chemists have developed a simple method for commercially attractive carbon capture using metal-organic frameworks (MOFs). Due to their nanopores, the MOFs have a wide range of applications, including separation of petrochemical products, DNA imitation and extraction of heavy metals and even gold from water. The technique developed by Professor Agrawal from EPFL Valais Wallis has significantly improved the gas separation performance of the ZIF-8, particularly in terms of "carbon capture". This process captures CO_2 emissions from fossil fuels and prevents them from entering the atmosphere.

A moon mission in the ice of Zermatt

The IGLUNA, coordinated by the Swiss Space Center of the EPFL as part of a pilot project of the European Space Agency (ESA_Lab@), has brought together more than 150 students on a single topic, a "habitat in the ice", potentially transferable to the moon. After working for months on the design of technologies to meet the challenges of human life in this extreme environment, students from EPFL and twelve European universities came together in Zermatt in June 2019 to build their lunar habitat and present it to the public. The second round of this cross-disciplinary project was launched in September, based on the experience of IGLUNA 2019.



Ultra-thin MOF membrane on a commercial polymer substrate.
› K. V. Agrawal / EPFL

The scientific and technical projects were set up in the Glacier Palace on the Matterhorn.
› Jamani Caillet / EPFL

PSI

THE "JUNGFRAU" ON TOP OF THE WORLD

The SwissFEL, the PSI's latest large-scale research facility, boasts sophisticated X-ray laser technology, as well as refined sensor systems. In addition to materials science, environmental and energy research, life sciences in particular will benefit from the new possibilities offered by the 750 metre-long facility.

One of the most exclusive attractions in Switzerland lies tucked away in woodland in Würenlingen. "If there's one thing they're jealous of us for in Japan or the USA, it's this," says Professor Gebhard Schertler pointing at the "Jungfrau", which stands gleaming with shimmering surfaces, cables and flashing LEDs in the middle of the room. It is an innovative, two-dimensional pixel detector for high-performance research with X-ray light, which was developed for the SwissFEL. The detector conceals the extremely high-precision measurement sensor systems for the X-ray light pulses that are produced in the facility, which is almost 750 m long and which lies hidden beneath the ground in the wood. The SwissFEL is the Paul Scherrer Institute's (PSI) most recent large-scale research facility. It can be used to generate extremely short and intense pulses of X-ray light. The process opens up completely new possibilities for researchers; for example, they will be able to record structural changes in biomolecules "in real time" for the first time ever.

The area of woodland where the facility is located borders the PSI site, just a short walk away. Schertler takes real pride in showing it off. He is Head of the Biology and Chemistry research division at the PSI and is responsible for using sophisticated biological experiments to get the maximum potential out of the PSI's measuring instruments. The researchers are particularly interested in the new ways to decipher the structure of protein molecules. The spatial structure of proteins has been successfully studied for some time now using the protein crystallography technique on the PSI's Swiss Light Source (SLS). However, proteins are not rigid objects, but perform movements that last between femtoseconds and a few seconds. Schertler and his colleagues' aim is to capture images of the proteins in motion. After all, if we know how changes in the structure of a protein affect its function, we can also find out how a drug works or why a disease develops.

The PSI's "Jungfrau" is rated among the "top of the world": an innovative, twodimensional pixel detector for high-performance research with X-ray light for the SwissFEL.

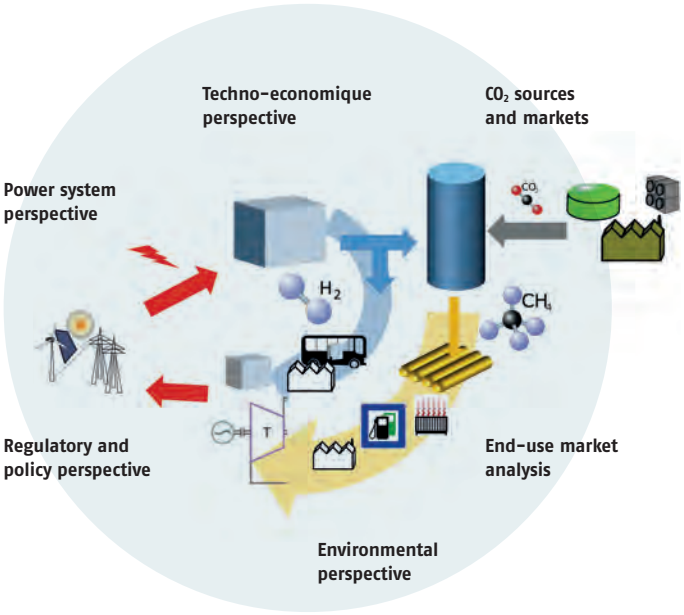
In order to "film" structural changes, the first thing to do is to integrate many proteins into many crystals in which they are arranged in a regular lattice structure. Now you have to get the proteins to start moving at the same time. The best way to do this is with light-activated proteins that occur naturally. First of all, the proteins are excited by short laser pulses of visible light in order to make them move synchronously. They are then measured with the X-ray pulse from the SwissFEL. If the time span between activation and measurement is changed, it is possible to "record" a protein structure at any point during its movement and thus turn molecular snapshots into a "molecular film".

The time resolution that researchers achieve with their experiments at the SwissFEL is currently several hundred femtoseconds. One femtosecond is a quadrillionth of a second. The time resolution indicates the time interval between two consecutive images in the virtual "film" that visualises the movement of the proteins. A higher time resolution means that even faster processes can be observed in the proteins. Schertler considers up to 50 femtoseconds to be a challenging goal.

In this sense, the facility buried away in the forest is the focus of a potentially revolutionary breakthrough in life sciences. As Schertler puts it, "life is dynamic. Structural changes in proteins are the basis for every living system and are the drivers of all life processes." There has been little access to these dynamic processes up to now. It is like reaching a new continent.

One of the most important tasks in Schertler's remit is not only to map this continent, but also to explore it further. Schertler and his colleague Gregor Cicchetti firmly agree that the findings are of immense relevance for life sciences. These processes are difficult to observe with classical biological techniques. But the SwissFEL will only be able to demonstrate its strengths in combination with other analytical techniques, such as modern spectroscopy or electron microscopy. Schertler calls it "integrative structural biology".

Schertler feels certain that the latest successes are only the beginning. At some stage, it will be possible to observe biological structures in situ, i.e. in their natural cellular environment rather than in a crystal or in a pure protein solution at atomic resolution. Only a research institute such as the PSI would be able to achieve a goal as ambitious as this. The PSI traditionally also carries out long-term research projects.



Power-to-X at a glance.
› Jörg Roth / PSI

The energy system of the future

PSI researchers have collaborated with colleagues from ETH Zurich and Empa as well as from four other Swiss universities and research institutions to produce the new white paper entitled "Power-to-X" for the Federal Energy Research Commission (CORE). The white paper seeks to provide the most important existing findings on Power-to-X technologies. Processes of this kind use electricity from new renewable energies to produce hydrogen (H_2) or methane (CH_4) and thus to store surplus energy. The study sheds light, among other things, on the potential of Power-to-X technologies for the 2050 energy strategy, the challenges facing the technology and the factors that favour its uptake.

A compass pointing west

Researchers at the PSI and ETH Zurich have discovered a special phenomenon of magnetism in the nano range. The atoms act like tiny compass needles and exert their effect over extremely short distances in the range of a few millionths of a millimetre. That is why researchers use the term nanomagnets. The phenomenon that PSI researchers have now been able to observe is based on interaction that was predicted more than 60 years ago. In this interaction, the tiny compass needles align not only along the north-south axis, but also along the east-west axis. What is unusual is that this interaction takes place laterally, that is laterally on one plane. Previously, comparable couplings between nanomagnets only used to be detected vertically, with groups of atoms arranged one above the other. The discovery allows magnets to be assembled in unusual configurations. This could be used to build computer memories and switches and thus increase the performance of microprocessors.

Preventing tumours from metastasising

PSI researchers and colleagues from the F. Hoffmann-La Roche AG pharmaceutical company have taken an important step towards developing a drug to combat the metastasis of certain types of cancer. With the help of the Swiss Light Source (SLS), they decoded the structure of a receptor that is crucial for the migration of cancer cells. This makes it possible to identify active substances that could prevent the spread of certain cancer cells via the body's lymphatic system, for example the metastasis of certain common cancers such as colon cancer.

Steffen Brünle (right) and Jörg Standfuss at the device for separating the receptor protein, which is to be characterised, from cell extracts.
› Markus Fischer / PSI

WSL

ACCELERATING RESEARCH

How do you make valuable environmental data more accessible? The WSL is mounting a data offensive and setting up a platform called EnviDat. An initiative that has many hurdles to overcome.

Data, data, data. Not only does it make the new economy buzz, it's also the oil that keeps the engine running in scientific research. And that's what makes the WSL Environmental Data Portal (EnviDat) so exciting: environmental data is one of the oldest data series in science. "We have a long tradition of measuring and monitoring at WSL," says Gian-Kasper Plattner, programme manager at WSL, who is heading the project. Some of these measurement series date back a century or more and are still being updated. However, a historical comparison also reveals cultural changes: whilst these data series used to be archived in thick tomes, they are suddenly available worldwide in digital form, without any great hurdles. Or theoretically at least. In practice, there are still a few stumbling blocks. Therefore, WSL decided a few years ago to set up the EnviDat central data hub, geared towards the needs of users. The website is freely accessible and already holds around 250 data records. According to Plattner, the idea has been to make the data visible so that it could also be used by the "public".

To start with, the service is aimed at peers, of course. Research innovation is the stated purpose: "We want research to be accelerated." It sounds like an open science advertising slogan at first: for as comprehensive and simple an exchange of data as possible. But Plattner qualifies that straight away: "We were not instructed to launch an open science initiative, even though we support open science with EnviDat. We had to build a data portal that created added value by linking the metadata." So, EnviDat is not just an IT solution, it is chiefly a service to researchers. According to software engineer Ionut Iosifescu, the aim is to provide advice and tools rather than to evangelise about the idea of completely open data. The crucial thing is that the authors of the data can rest assured that they will be rewarded for their work.

Gian-Kasper Plattner, Head of Research and Project Manager for EnviDat (left) and his colleague and software engineer, Ionut Iosifescu.

Making research data available means additional work in the first place: data acquisition must be documented accordingly, including good metadata. Is the benefit worth the effort, including for producers? In order to do this, we need to find a way of managing data citations, akin to citing scientific publications. "The research community still has to find out precisely how to guarantee this with research data, and how to define it." It is interesting to note that Plattner does not perceive a generation gap. Younger researchers are sometimes even more conscious of these problems; they are aware of the competitiveness of the research environment. Could someone else end up taking credit for the hard work involved in collecting data if it is made public too early? WSL data must be made available after two years at the latest; this has been agreed.

Does that not ultimately encourage data fragmentation if each institution builds its own platform? In fact, many research institutions have similar plans, but in practice they can vary considerably. Plattner mentions the Eawag data initiative ERIC (The Eawag Research Data Institutional Repository), which also focuses on internal data management. Plattner is rather sceptical about efforts to centralise this at this stage. It is easier to build trust if you are closer to the researchers and support them in finding suitable solutions.

The problem of fragmented data and data portals is also in evidence at WSL. The solution? Extensive linking and networking with harvesters: meta-platforms that access data from various sources, such as the environmental data portals of ESA and NASA. This in turn touches on the big issue of data homogeneity. However, you have to be careful here, for example if different measuring instruments are used, explains Plattner. Aggregation to comprehensive, consistent data set would just not be possible, in that case. Iosifescu mentions another eternal problem: "We have not yet found a way of standardising the data keywords." Plattner sees EnviDat as a vital first step on a "long, long road". The first thing is to find out what "open science" that meets the needs of data producers and users could look like in practice.

A single gram of Central European forest soil contains several thousand species, including the millipede.
› WSL

Biodiversity in soil is good for woodland performance

The greater the biodiversity of soil organisms, the more effectively a forest can perform its tasks – for example as a water and air filter, as a bulwark against natural hazards or as a recreational area. This is demonstrated by a comprehensive meta-analysis as part of a COST (European Cooperation in Science and Technology) initiative in which WSL was involved. One gram of central European forest soil contains as many different organisms as you might find on one square kilometre of the earth's surface: several thousand species of bacteria and fungi, as well as numerous small fauna and millipedes. Subterranean biodiversity is almost always associated with positive effects because it acts as a back-up for ecosystem activities. As the biodiversity of the soil is also under threat, it is important to understand this.

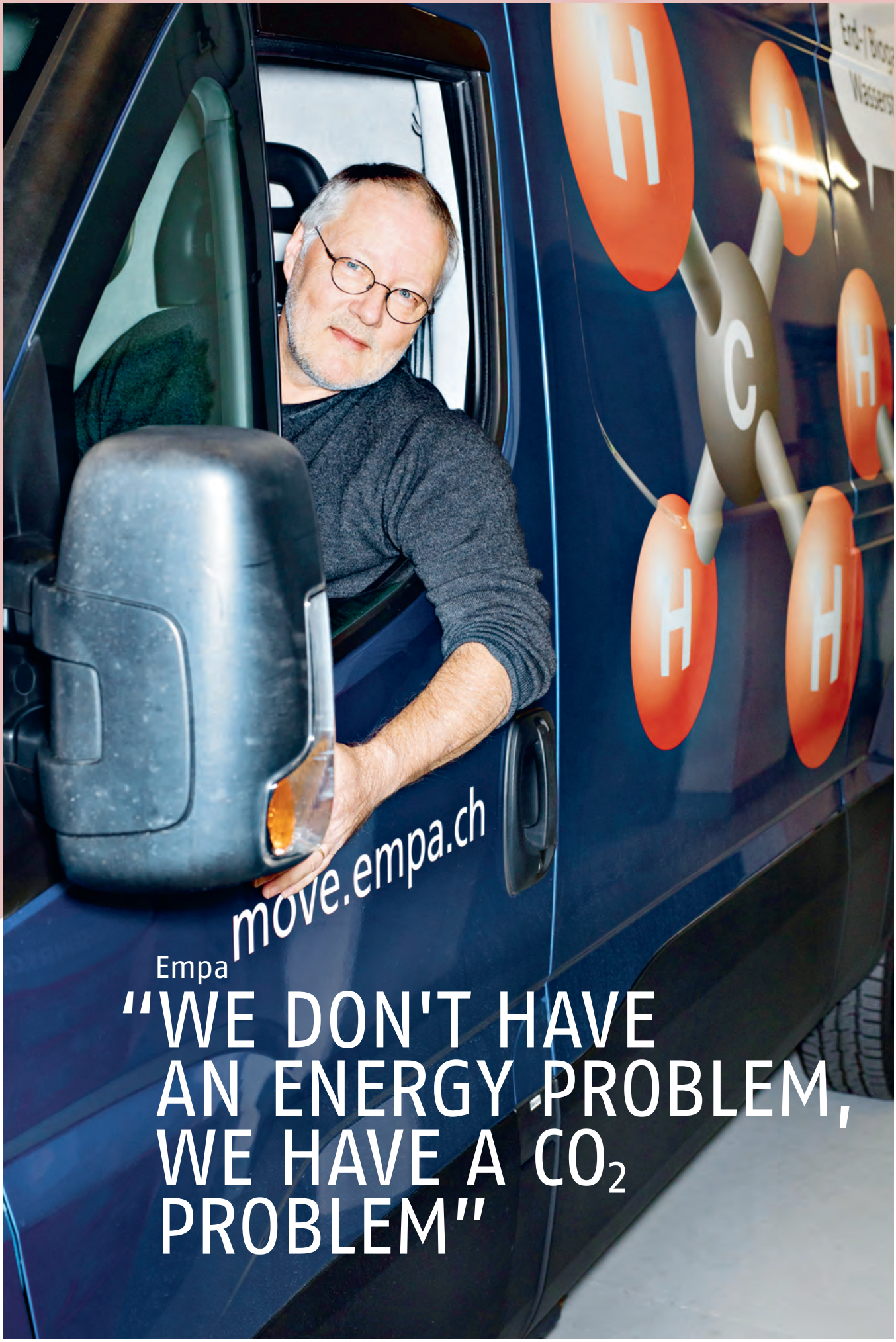
One third of the volume of a glacier could be saved

About half of the volume of glaciers in the Alps will have disappeared by 2050 – quite independently of how much greenhouse gas emissions are reduced by, as the glaciers react more slowly to warming. However, further development will depend on the quantity of greenhouses gases emitted by mankind in the future and how strong the effect of global warming is. The Alps would be largely ice-free by 2100 in a highly warming scenario. Under moderate warming, on the other hand, about one third of the current volume of ice could be saved: although the future of glaciers is at risk, it is still possible to mitigate losses. These current and detailed estimates of the future of the 4,000 or so Alpine glaciers were produced by three researchers from WSL and ETH Zurich. They made use of observed data and a new computer model that combines ice flow and melting processes.

Modern fungus monitoring with genetic methods

Switzerland is planning to update the "Red List" of fungi. WSL is developing new methodology for this. Up to now, experts have repeatedly searched the terrain for fungal fruiting bodies and identified them individually, in some species painstakingly under the microscope. Using a genetic method known as next generation sequencing, the entire fungal community can now be identified in a single environmental sample. Thus, the species can be detected in the soil, even if there are no fruiting bodies visible above ground; or they can be detected using special apparatus that filters spores from the air. Preliminary trials with active and passive spore traps on a meadow that is very rich in fungi have already been successful.

Automatic spore traps filter spores from the air.
› Markus Schlegel / WSL



Empa

"WE DON'T HAVE AN ENERGY PROBLEM, WE HAVE A CO_2 PROBLEM"

He is Empa's expert on vehicle drive systems: as head of the Automotive Powertrain Technologies laboratory, Christian Bach and his team are looking for ways to convert road traffic from currently being based almost entirely on fossil fuels over to renewable energy in the future.

A conversation with Roland Fischer.

Mr Bach, mobility is crucial in tackling the climate crisis. Why? If we are seeking to have a CO_2-neutral economy by 2050, this primarily means that we have to stop using fossil fuels from that date onwards. Mobility accounts for the highest proportion of fossil fuels in Switzerland. However, mobility will only become more climate-friendly with the additional production of renewable energy. Otherwise, we run the risk of other sectors "stealing" clean energy.

Can this be achieved with current climate-friendly technologies? We can get most of the way there by switching to renewable energy. However, the net zero target is very ambitious. We will not be able to avoid extracting additional CO_2 from the atmosphere. In nature, there is a permanent balance between CO_2 sources and sinks. The original sin of climate change is that we have tapped fossil sources on a large scale without creating corresponding sinks.

Sinks? Mobility as an "energy consumer" has a role to play here? It is not only possible – it has to be done. For example, there is intensive discussion about the recovery of CO_2 from the atmosphere in Power-to-X concepts. We are currently planning to construct a system of this kind. Hydrogen, which is produced from excess electricity temporarily or locally, can be converted into energy carriers such as methane or liquid hydrocarbons, which can then be used to replace natural gas, diesel or kerosene. The great model for this process is photosynthesis.

Aren't synthetic fuels inefficient? Why not run electric cars directly on renewable energy? In the future, electric mobility will cover a large part of road mobility, but not long-distance and heavy goods travel. In addition, electric and hydrogen mobility in winter will also depend on the supply of imported, renewable energy, and we believe that this is only possible with synthetic energy sources. To cut a long story short, it takes both!

Why can't surplus electricity be stored in the power system? Surpluses can be stored briefly using pumped storage power plants and batteries. The additional storage capacities required for day/night balance is already enormous. In this area, electric vehicles could bring system benefits by using their batteries.

And do we put the rest into synthetic energy sources? Precisely! Although this has a poor degree of efficiency, it offers the impressive advantage that the surplus electricity can be shifted to other energy sectors where it can replace fossil fuels. More CO_2 could be extracted from the atmosphere and converted into storable limestone, which is why even energy sources with negative CO_2 emissions could be achieved.

So, will we be producing these fuels locally? Not only locally. However, we are also looking at the possibility of large-scale plants in desert regions. If 50% of the miles driven on the roads of the world were powered by electricity and 50% by synthetic fuels, significantly less than one percent of the world's desert area would have to be equipped with solar systems to produce these synthetic fuels.

And we would be rid of the CO_2 problem in road transport! It's important to keep saying that we don't have an energy problem on Earth, we have a CO_2 problem.

Isn't it too expensive to extract CO_2 from the atmosphere? The economic feasibility of synthetic fuels is a major challenge indeed. But the most significant cost block is electricity, not CO_2 costs. The overall costs are manageable, especially in the area of road transport, where energy costs are very low.

That sounds technically convincing. What are the chances of the proposal in the political and economic reality? As soon as economic concepts are enshrined in law, implementation can begin. The draft CO_2 law in Switzerland is a first piece of the puzzle. There will certainly be a need for more of this, especially in large countries. Which makes me feel confident that we will see a positive attitude in environmental circles and in the car industry.

Will we be able to keep driving powerful engines with a clear conscience? It is evident that synthetic fuels are more expensive than fossil fuels. That's why synthetic fuels will increase the push towards more fuel-efficient vehicles. However, there are other aspects, such as traffic at a gridlock. There is no getting around the need to fundamentally rethink mobility. We assume that the technical measures mentioned will be complemented by non-technical initiatives such as car sharing, mobility pricing and automated vehicles, especially in cities.

How do you think your efforts to convince people are going to work in the political arena? I think that the discussion is too focused on the advantages and disadvantages of individual technologies. However, if we wish to lower CO_2 emissions to zero, the drive technology is of secondary importance. First and foremost, we need to switch from fossil fuels to renewable energy. This is as simple as it is crucial. This requires a political consensus that is still lacking today. The market itself can decide which technology is to be used where.

Safe high-performance batteries

Solid-state batteries are seen as the energy stores of the future: they can be charged more quickly than existing Li-ion batteries, can absorb larger amounts of energy and are safer because they are not flammable. Researchers at Empa have developed a new method of manufacturing solid-state sodium batteries, for which they received several awards in 2019, including the *Mercedes-Benz* Battery Division Research Award from the Electrochemical Society and the Impact Award from the University of Geneva. Empa entered into a strategic partnership with the Fraunhofer Society in 2019 to bring this technology for traction batteries in electric cars to market maturity. The aim is to bring the key technology (back) to Europe.

Soft shell, hard core: the flexible structure of the drone is filled with artificial intelligence.
› Beat Geyer/Empa

Drone researcher Mirko Kovac heads the new Materials and Technology Center of Robotics at Empa.
› Empa

Drones for infrastructure monitoring

Researchers at the new Materials and Technology Center of Robotics at Empa and Imperial College London are developing innovative robot and drone systems for infrastructure maintenance and environmental monitoring. The drones use the NEST research building as a flying arena. As the "immune system" of the building, they independently search for repair needs and carry out the necessary work precisely, making maintenance simpler and more efficient. The researchers take inspiration from biological concepts; in some ways, the drones resemble birds of prey or spiders. And thanks to artificial intelligence, the flying robots are able to respond to their environment in real time.

3D printing for implants and sensors

Nanocellulose from wood has amazing properties. Empa researchers equipped the biodegradable material with additional capabilities to produce implants for cartilage diseases, such as an auricle, using 3D printing. In addition, the researchers developed flexible sensors made of nanocellulose that lie against the skin in order to measure important metabolic values for medical diagnoses. Silver particles that conduct electricity are added to nanocellulose for this purpose. The sensor transmits the data to a computer in order to analyse the measured values. The biochemistry laboratory on the skin is only half a millimetre thick. Portable sensors are currently being developed in collaboration with ETH Zurich, EPFL and CSEM to investigate movement sequences, for example after joint operations.

Maryna Bodnarchuk develops cost-efficient high-performance batteries from materials that are readily available.
› Empa

3D-printed ear: Michael Hausmann uses nanocellulose as a basis for new implants.
› Empa

EAWAG

EXCELLENT ALTERNATIVES FOR ANIMAL TRIALS

Toxicity tests are currently still carried out mainly on livestock. Within the context of environmental risk assessment, this is done most commonly on fish. An alternative method developed by Eawag researchers is currently overcoming crucial hurdles to its widespread use in practice. Thanks in part to the persuasive efforts of the scientists involved.

How do you measure whether a chemical substance is safe for the environment? By exposing live fish to increasing doses of this chemical until they finally die. And how do you measure whether the water from wastewater treatment plants is really clean? By keeping fish as living sensors. They indicate if there are problems with the water quality, as an early warning system, so to speak.

Professor Kristin Schirmer, Head of the Environmental Toxicology Department at Eawag, had long come to realise that there would have to be another way of doing this. She calls the current standard procedure for measuring water quality an "outmoded, crude test". Nevertheless, the so-called acute fish toxicity test is one of the most widely used tests in environmental regulation. Schirmer is convinced that it is time to change this. So how do you make sure that any danger is detected without experimenting on living organisms?

Schirmer and her team have established a method involving a cell line from the gills of rainbow trout. They proceeded on the assumption that acute fish toxicity mainly affects the gill cells in the fish. The method that has since been established is something like a standardised fish substitute that can be used in different laboratories and should provide the same results everywhere. The breakthrough came with a round-robin test in various laboratories around the globe. The scientific article on this was published in the respected journal "Toxicological Science" in April 2019. Schirmer and her team have demonstrated that the methodology, which has long been established in their own laboratory, works reliably and can also be reproduced in other laboratories.

It is good for consumers and fish – and supports further progress. The USA has the ambitious goal of phasing out animal testing altogether by 2035.

The gill cells can be tested for vitality using fluorescent dyes. In doing so, they react to a whole spectrum of chemical substances in a similar way as living fish. "This has confirmed our assumption that toxins initially affect the gills," said Schirmer. There were a few outliers, particularly with some neurotoxic substances. Eawag researchers are, therefore, planning to extend the procedure to include nerve cells. They are already conducting intensive studies on the effects of chemicals using cell lines from the liver and intestine of rainbow trout. They are also experimenting with the cultivation of cells on chips, on which cell vitality can be measured in real time on the basis of the electrical resistance provided by the cells. These chips should also make remote-controlled, fully automatic measurements possible. "Our vision is to fully simulate a living fish by combining different cell types," said Schirmer. Her team is already working on the possibility of using computer programs to investigate the effects of chemicals in the future.

As ruthless as the current test may appear, at least it measures what it is supposed to measure. Or does it? "It's an illusion to assume that every test with live fish yields clear results," says Schirmer. Because the test is primitive both in terms of its concept and its validation. In terms of comparability and reliability, the new test is much more stringent, and the requirements placed on laboratories are more rigorous. This has persuaded specialists to get behind it. It has already attracted a great deal of interest from industry. The round-robin test was co-financed by the European Chemical Association. After all, the revolution would not only mean fewer animal experiments, but also simpler, cheaper and more standardised methodology. Specific test requests soon followed from industry, and Schirmer, together with her laboratory assistant Melanie Fischer and Eawag postdoctoral student Stephan Fischer, founded the Eawag spin-off aQuaTox-Solutions back in 2016.

The matter was "actually concluded from a research perspective" with the publication of the round-robin test. Nevertheless, Schirmer and her team will continue to invest a great deal of time in the project to ensure that the methodology is actually applied in practice. She is extremely motivated by the prospect of bringing something so important to society. Thus, she made regular visits to certification authorities and learnt how to convince not only her peers from the research community and technical experts on various commissions. The combined research and lobbying efforts ultimately led to the first toxicity test using cultured gill cells being ISO-certified in 2019. This earnt the researchers the 3Rs Award 2019 by the 3R Competence Centre Switzerland (3RCC). And Schirmer is confident that further progress will now be made quickly. She is currently working with experts on the certification of the gill cell test by the OECD.

aquatox-solutions.ch

Water temperatures via a 3D model

The current water temperatures in Lake Zurich and how they will develop over a few hours and over the next few days have been published on the website www.meteolakes.ch as of this year. Researchers from Eawag and EPFL have published a publicly accessible 3D model that uses current and forecast data from MeteoSwiss, hydrological data from the Federal Office for the Environment (FOEN) and satellite data to show lake water temperatures. The temperatures are calculated for different depths and with a time resolution of three hours. The lake models can look five days ahead. Up to now, models have been created for Lake Geneva, Lake Biel and Lake Greifen. Lake Zurich has now been added. Damien Bouffard from Eawag's Department of Surface Waters heads the Coresim project that is behind Meteolakes. The researchers are aiming to create added value for other scientists. Nowadays, many lakes are only measured on a monthly basis. Researchers who want to link their own data, like the distribution of nutrients in the lake, with lake physics, can now access high-resolution data thanks to Meteolakes.

Self-powered sensors detect water leaks

Around the world, a lot of water is lost every year due to problems in the water infrastructure. This is why efficient monitoring of water distribution networks is the subject of research work. Eawag has worked with ZHAW to develop a battery-free solution that monitors water resources in real time. "ADAWIM" (Autonomous and Distributed Architecture for Water Infrastructure Monitoring) is based on wireless smart sensor technology. The system does not come into contact with the water, but mainly obtains energy from temperature differences in the operating environment, for example between the water or wastewater pipe and the soil. The system has already been used in Eawag's demonstration systems and in the infrastructure provided by the *Stadtwerk Winterthur* utility company. The research team has shown at all sites that ADAWIM can generate enough energy to measure parameters such as water flow or soil moisture.

Insect diversity in alpine rivers endangered

Dams, weirs, water intakes – the rivers in our Alpine region are widely obstructed due to the use of hydropower. This changes the drainage and sediment dynamics and thus also the occurrence of fauna and flora. In order to keep the ecological impact as low as possible, it is important to guarantee sufficient residual water quantities and to restore the natural sediment dynamics. A new study conducted by Eawag and the University of Lausanne now shows the following: it is especially important in the case of water intakes to regulate sediment inflow to ensure the survival of stream inhabitants. This is because a lot of sand and gravel builds up at a water intake. In heavily glaciated catchment areas, the volume is so high that the catchments have to be flushed up to 17 times a day to empty the sediment traps. With dire consequences: the researchers could barely find any life in the Borgne d'Arolla during the summer. The reason for this is the large quantities of coarse and fine sediment that bury the animals underneath.

Dr Frank Blumensaat (Department of Urban Water Management) uses ADAWIM to measure the water flow wirelessly in the experimental set-up.
› Patrick Cipriani / ZHAW

A water intake in the Borgne d'Arolla alpine river system in the Valais.
› Chrystelle Gabbud

GOVERNANCE

Structure and leadership of the ETH Domain

The Federal Government operates the Federal Institutes of Technology in accordance with the Federal Constitution (Art. 63a Para. 1). As this is the law governing the ETH Domain, the ETH Act defines this mission. Together with Art. 64 Para. 3 of the Federal Constitution, it also forms the legal foundation for operating the four research institutes of the ETH Domain.

The ETH Domain: Legal basis

The Federal Act on the Federal Institutes of Technology of 4 October 1991 (ETH Act) defines the status, structure and mission of the ETH Domain. The ETH Domain is autonomous within the framework of the law and it is affiliated to the responsible government department pursuant to the ETH Act. This has been the Federal Department of Economic Affairs, Education and Research (EAER) since the beginning of 2013. The ETH Act defines the autonomy of the two Federal Institutes of Technology and the four research institutes. The ETH Board is the strategic governing and supervisory body of the ETH Domain.

The State Secretariat for Education, Research and Innovation (SERI) opened a consultation on the partial revision of the ETH Act in November 2018 with a dispatch to that effect. New regulations are under discussion, in particular those concerning the implementation of recommendations of the Swiss Federal Audit Office (SFAO) regarding the general oversight competencies of the ETH Board and two corporate governance guidelines (restriction of voting rights and absence of institutional members of the ETH Board). Further adaptations include various personnel policy changes (in particular for employment after retirement and for the renewal of fixed-term employment contracts), the creation of a legal basis for the sale of surplus energy generated or purchased for the institution's own use, for disciplinary measures, as well as for security services and video surveillance. The changes in the law are likely to come into force at the start of 2021.

Structure of the ETH Domain

*employment contracts including doctoral students, as of 31 December 2019

ETH Domain

ETH Board
11 members
55 employees (staff, Internal Audit, Internal Appeals Commission)

Federal Institutes of Technology

ETH Zurich
22,193 students and doctoral students
12,280 employees*

EPFL
11,449 students and doctoral students
6,119 employees*

Research institutes

PSI
2,072
employees*

WSL
533
employees*

Empa
1,033
employees*

Eawag
507
employees*

Tasks and leadership
According to the purpose set out in Art. 2 of the ETH Act, both Federal Institutes and the four research institutes (institutions of the ETH Domain) must educate students and specialists in scientific and technical fields and ensure continuing education, expand scientific knowledge through research, foster the development of junior scientific staff, provide scientific and technical services, perform public relations work, and make use of their research results.

The institutions of the ETH Domain discharge their mission in observance of internationally recognised standards. They take account of Switzerland's needs and promote international cooperation.

Strategic objectives and expenditure ceiling
The political leadership of the ETH Domain rests with the Federal Council and the Federal Parliament. The central leadership tools are the Dispatch on the Promotion of Education, Research and Innovation (ERI Dispatch) and the associated strategic objectives set by the Federal Council for the ETH Domain. The political tools are supplemented by financial controlling, which provides information on financial reporting and mission fulfilment.

Reporting
The ETH Board reports annually to the Federal Council and shows in particular how the ETH Domain has used the annual total federal financial contribution with reference to the strategic objectives. Based on the ETH Board's report, the Federal Council informs Parliament within the scope of its modular reporting with a summary report and a detailed report. In a self-evaluation report in each half of the ERI period, the ETH Board indicates the extent to which the strategic objectives of the Federal Council have already been met. This self-evaluation report serves as the basis for the evaluation of the ETH Domain by outside experts (peer review) which is to be carried out by the EAER.

Along with the application for funding for the next ERI period, the EAER informs Parliament about the status of the achievement of goals in an interim report (Art. 34a ETH Act) produced half-way through the performance period. The ETH Board is responsible for the strategic leadership of the ETH Domain (see next section). The Executive Boards of both Federal Institutes and the Directorates of the four research institutes are responsible for the operational leadership of the individual institutions of the ETH Domain. In accordance with Art. 4(3) of the ETH Act, the institutions of the ETH Domain assume all responsibilities which are not assigned to the ETH Board by the ETH Act.

ETH Board: Mission and operating principles
The ETH Board defines the strategy of the ETH Domain within the framework of the strategic objectives of the Federal Council, represents the ETH Domain when dealing with policy-makers and government authorities at federal level, issues directives about financial controlling, and carries out strategic controlling. It also approves the development plans of the institutions of the ETH Domain, oversees their implementation and supervises the ETH Domain (Art. 25 ETH Act). It agrees targets with the institutions and allocates federal funds on the basis of the institutions' budget requests (Art. 33a ETH Act). It submits requests to the Federal Council for the selection or reselection of the Presidents of the two Federal Institutes of Technology and of the Directors of the four research institutes (Art. 28(1) and (7) ETH Act). It also appoints the other members of the Executive Boards of the two Federal Institutes of Technology and of the Directorates of the four research institutes (Art. 28(4) and (7) ETH Act). Finally, the ETH Board appoints professors at the request of the Presidents of both Federal Institutes of Technology (Art. 14(1) and (3) ETH Act).

The ETH Board performs its supervisory function through the use of the following tools: periodic reporting by the institutions on resources (finances, personnel, real estate), annual reporting by the institutions on the extent to which they have fulfilled their duties with regard to target agreements, annual discussions (known as dialogues) between the ETH Board and the institutions of the ETH Domain within the scope of strategic controlling, handling supervisory complaints addressed to it while observing subsidiarity and institutional autonomy, as well as reports by the institutions within the scope of their risk-management systems. Moreover, the ETH Board's "Internal Audit" staff evaluate the risk management processes, internal control system and governance processes of the institutions and report on them to the ETH Board.

The rules of procedure of the ETH Board are published in the compilation of Federal law. The ETH Board usually meets five times a year for two days at a time, and arranges additional meeting days for dialogues with the institutions of the ETH Domain. The President of the ETH Board is responsible for holding periodic individual discussions with the Presidents of the two Federal Institutes of Technology and with the Directors of the research institutes.

Discussions are held twice a year between the proprietor, represented by the EAER and the Federal Department of Finance (FDF), and the ETH Board, represented by its President.

Management bodies of the ETH Domain

Presidency and Members of the ETH Board
- Fritz Schiesser[1], President (until the end of April 2019)
- Beth Krasna[1,2], Acting President (from May 2019 until January 2020)
- Prof. Dr Dr h. c. Barbara Haering[2], Acting Vice President (from May 2019 until January 2020)
- Prof. Dr Joël Mesot[1]
- Prof. Dr Martin Vetterli[1]
- Prof. Dr Gian-Luca Bona[1]
- Dr Kristin Becker van Slooten[1]
- Marc Bürki[2]
- Beatrice Fasana
- Prof. Dr sc. nat., Dr h. c. mult. Susan Gasser
- Christiane Leister

[1] Member of the Executive Committee
[2] Member of the Audit Committee

At the end of January 2020, Beth Krasna handed over her post to Prof. Dr Michael O. Hengartner, who took over as new President of the ETH Board in February 2020.

Executive Board of ETH Zurich
- Prof. Dr Joël Mesot, President
- Prof. Dr Sarah Springman, Rector
- Prof. Dr Detlef Günther, Vice President for Research and Corporate Relations
- Dr Robert Perich, Vice President for Finance and Controlling
- Prof. Dr Ulrich Weidmann, Vice President for Personnel and Resources

Executive Board of EPFL
- Prof. Dr Martin Vetterli, President
- Prof. Dr Pierre Vandergheynst, Vice President for Teaching
- Prof. Dr Andreas Mortensen, Vice President for Research
- Prof. Dr Marc Gruber, Vice President for Innovation
- Caroline Kuyper, Vice President for Finance
- Dr Etienne Marclay, Vice President for Personnel and Operations
- Prof. Dr Edouard Bugnion, Vice President for Information Systems

Directorate of the PSI
- Dr Thierry Strässle, Acting Director[3]
- Prof. Dr Leonid Rivkin, Deputy Director
- Prof. Dr Gabriel Aeppli, Member
- Dr Peter Allenspach, Member
- Prof. Dr Andreas Pautz, Member
- Prof. Dr Christian Rüegg, Member
- Prof. Dr Gebhard F. X. Schertler, Member

Directorate of WSL
- Prof. Dr Konrad Steffen, Director
- Dr Christoph Hegg, Deputy Director
- Dr Anna Hersperger, Member (since May 2019)
- Prof. Dr Rolf Holderegger, Member
- Prof. Dr Andreas Rigling, Member
- Dr Jürg Schweizer, Member
- Prof. Dr Niklaus Zimmermann, Member

Directorate of Empa
- Prof. Dr Gian-Luca Bona, Director
- Dr Peter Richner, Deputy Director
- Dr Brigitte Buchmann, Member
- Prof. Dr Alex Dommann, Member
- Dr Pierangelo Gröning, Member
- Dr Urs Leemann, Member
- Dr Tanja Zimmermann, Member

Directorate of Eawag
- Prof. Dr Janet Hering, Director
- Prof. Dr Rik Eggen, Deputy Director
- Prof. Dr Jukka Jokela, Member
- Prof. Dr Tove Larsen, Member
- Gabriele Mayer, Member
- Prof. Dr Alfred Johny Wüest, Member
- Prof. Dr Christian Zurbrügg, Member

[3] In January 2019, Dr Thierry Strässle took over as Acting Director of the PSI in place of the Director of the PSI who resigned at the end of 2018. Prof. Dr Christian Rüegg will take over the management of the PSI in April 2020.

Status as at 31 December 2019 (reference is also made to changes agreed in 2019 which will become effective in 2020).

Appeals body

ETH Internal Appeals Commission
The ETH Internal Appeals Commission decides on appeals against rulings made by bodies of the institutions of the ETH Domain (Art. 37 Para. 3 ETH Act). It is an independent judicial authority based in Bern and is administratively assigned to the ETH Board, to which it reports (Art. 37a ETH Act). Appeals mainly relate to matters arising from legislation on human resources and higher education. Appeals against the rulings of the ETH Internal Appeals Commission can be made to the Federal Administrative Court.

- Prof. Dr Hansjörg Peter, President (until the end of September 2019)
- Barbara Gmür Wenger, President (since January 2020)
- Dr iur. Esther Tophinke, Vice President (until the end of 2019)
- Consuelo Antille, Member (until September 2019)
- Prof. Dr Simone Deparis, Member (since January 2020)
- Jonas Philippe, Member
- Dr sc. nat. Dieter Ramseier, Member
- Prof. em. Rodolphe Schlaepfer, Member (until September 2019)
- Prof. Thomas Vogel, Member (since January 2020)
- Yolanda Schärli, Member

ETH Board support

Staff of the ETH Board
The ETH Board's staff support the ETH Board in fulfilling its legal mandate, particularly regarding strategic leadership, supervision, promotion of cooperation in the ETH Domain and liaising with the Federal authorities (Art. 26b ETH Act).

Executive Team
- Dr Michael Käppeli, Executive Director
- Dr Kurt Baltensperger, Head of Science
- Gian-Andri Casutt, Head of Communications
- Dr Dieter Künzli, Head of Finance and Personnel
- Dr Monique Weber-Mandrin, Head of Legal Services
- Michael Quetting, Head of Real Estate
- Barbara Schär, Head of ETH Board Secretarial Office

Internal audit
The ETH Board employs Internal Audit staff, as per Art. 35a^{ter} ETH Act. It conducts the internal audits of the institutions of the ETH Domain.
- Patrick Graber, Head

Audit and Executive Committees
The Audit Committee assists the ETH Board in financial supervision and in the monitoring of risk management, of the internal control system and of financial auditing activities. As a rule, it is composed of two to three "external" ETH Board members who are independent of the executive leadership, but may also involve additional people in a consultative capacity. The President of the ETH Board, the head of the Internal Audit department and the head of the Finance section of the ETH Board's staff attend the meetings in an advisory capacity.

The Executive Committee assists the ETH Board in particular in preparing for and following up on meetings, and in fulfilling its duties as an employer. It also liaises with the social partners. It is composed of the President of the ETH Board (chair), the Presidents of both Federal Institutes of Technology, the representative of the research institutes and the delegates of the University Assemblies. The Executive Director and, if necessary, other members of the ETH Board's staff attend the meetings.

Remuneration of the ETH Board
The former President of the ETH Board received a salary of CHF 289,604 for his 80% FTE position, (CHF 362,005 for 100%) and CHF 96,535 for the period from January to April 2019 (the employer also paid social security contributions for this time period amounting to CHF 37,539). In addition, he received an entertainment allowance of CHF 1,666 pro rata, and the sum of CHF 72,402 for holidays not taken. The President was insured by the Swiss Federal Pension Fund, the rules of which determine the employer's contribution.

In the period from May to December 2019 the Acting President received until June 2019 a gross annual salary of CHF 181,002 for a workload of 50% (CHF 362,005 for a 100% FTE workload), CHF 181,365 (CHF 362,729 for 100%) from July onwards, or a total of CHF 120,849 for the period from May to December 2019 (in addition, the employer paid social security contributions of CHF 7,570 for this period).

The two Vice Presidents (former and acting), who are not employed by any of the institutions of the ETH Domain, each received a lump sum of CHF 26,000 (pro rata) for the periods from January to April and May to December 2019.

The other five members of the ETH Board who are not employees of any of the institutions of the ETH Domain each received a lump sum of CHF 20,000 in 2019. In addition, they were paid a total of CHF 43,000 for dialogue meetings and Audit Committee meetings (including a lump sum of CHF 6,000 for chairing the Audit Committee and for the audit of the annual financial statements). Their expenses were refunded on the basis of the ETH Board Ordinance of 11 April 2002 concerning the reimbursement of expenses in the ETH Domain. Those members of the ETH Board who are employees of one of the institutions of the ETH Domain do not receive additional fees for their activities on the ETH Board.

For the 70% FTE position, the ETH Board covered 40% of the wage and social costs (including compensation for expenses) incurred by EPFL for the delegates of the University Assemblies of both Federal Institutes of Technology, in order to guarantee the delegates' independence from either institution.

Monitoring and auditing

Internal control system
The institutions of the ETH Domain have an internal control system (ICS, Art. 35a^{bis} ETH Act). It was introduced using the template provided by the Federal Government. Its objectives are to protect the assets of the ETH Domain, to prevent errors and irregularities in accounting, and to ensure proper accounting and reliable reporting. It is an integral part of the audit by the Swiss Federal Audit Office (SFAO) or the auditors appointed by it. The focus is on financially relevant business processes.

Internal audit
The Internal Audit department conducts internal audits for the institutions of the ETH Domain (Art. 35a^{ter} Para. 1 of the ETH Act and Art. 11 of the Federal Audit Office Act). This department reports directly to the President of the ETH Board and its activities are supervised by the Audit Committee. The Internal Audit department provides independent, objective auditing services and supports the ETH Domain in achieving its aims. It is also responsible for coordinating and supporting the external audits of the ETH Domain.

Auditors
The SFAO performs external auditing duties for the ETH Domain (Art. 35a^{ter} Para. 3 of the ETH Act). In 2019, it audited the consolidated financial statements of both Federal Institutes of Technology, the consolidated financial statements of the ETH Domain and it conducted interim audits. The SFAO performs the audits of the research institutes jointly with PricewaterhouseCoopers (PwC). The SFAO's audit report on the consolidated financial statements of the ETH Domain comprises an audit report and a comprehensive report. These reports are discussed with representatives of the SFAO in the Audit Committee every year. In 2019, the SFAO invoiced the ETH Board for the total amount of CHF 589,626. CHF 369,890 for the 2018 annual review and CHF 219,736 for the interim audit of the 2019 annual financial statement).

Information policy
Its statutory role makes the ETH Board an interface between academia, policy-makers and society. Within its rules of procedure, the ETH Board undertakes to ensure honest, appropriate and transparent communication for the benefit of society and aims to explain its decisions and reinforce the role and reputation of the ETH Domain. Responsibility for this rests with the President. The key communication tools are the ETH Board's annual report to the Federal Government, the website www.ethboard.ch, targeted media relations work and the case-by-case illumination of relevant facts and positions, particularly regarding policies on education, research and innovation.

Beth Krasna
* 1953, Swiss/US citizen
Dipl. Ing.

Member of the ETH Board since 2003 and Acting President of the ETH Board (from May 2019 until January 2020). Independent board member.

Beth Krasna has a degree in chemical engineering from ETH Zurich and a Master's degree in management from the Massachusetts Institute of Technology (Cambridge, USA). She is member of the Board of Directors of Symbiotics SA as well as President of the Board of Directors of Ethos Services AG and of Xsensio SA. Additionally, Krasna is Vice President of the Foundation Board of the Graduate Institute of International and Development Studies in Geneva, and member of the Swiss Academy of Engineering Sciences.

Barbara Haering
* 1953, Swiss/Canadian
Prof. Dr sc. nat., Dr h. c. sc. pol.

Member of the ETH Board and of the Audit Committee since 2008, Acting Vice President of the ETH Board (May 2019 until January 2020) and President of the Audit Committee since May 2019. President of the Board of Directors of econcept AG since 2015.

Barbara Haering studied natural sciences and obtained a doctorate in spatial planning at ETH Zurich in 1996. She is President of the Board of Directors of econcept AG and member of the Board of Directors of Ernst Schweizer AG. In addition, she chairs the *Conseil d'orientation stratégique* at the University of Geneva and the Council of Foundation of the Geneva International Centre for Humanitarian Demining. Moreover, Haering is a member of the Foundation Council of the Swiss National Science Foundation (SNSF) and the University Council of Dresden University of Technology. She is a lecturer at the University of Lausanne.

Joël Mesot
* 1964, Swiss
Prof. Dr sc. nat.

Member of the ETH Board and of the Executive Committee since 2010. President of ETH Zurich since 2019.

Joël Mesot studied physics at ETH Zurich, obtaining a doctorate in solid-state physics in 1992. He was awarded the ETH Zurich Latsis Prize in 2002 and the Swiss Physical Society (SPG) IBM Prize in 1995. After research residencies in France and the USA, he came to ETH Zurich and joined the PSI, where he became Head of the Laboratory for Neutron Scattering in 2004. He was director of the PSI from 2008 to 2018. Mesot represents ETH Zurich on various national and international advisory boards. He is a member of the Advisory Council on Digital Transformation of the Federal Council and a member of the Foundation Board of the Swiss Innovation Park and senator of the Helmholtz Association
› Markus Bertschi / ETH Zurich

Kristin Becker van Slooten
* 1962, Swiss / German
Dr

Member of the ETH Board and of the Executive Committee since 2017. Representative of the university assemblies of ETH Zurich/EPFL on the ETH Board. Project head of equal opportunities at EPFL since 2017. Maître d'enseignement et de recherche (MER).

The environmental scientist Kristin Becker van Slooten studied Biology at the University of Geneva and obtained her doctorate in Environmental Chemistry and Ecotoxicology at EPFL. From 1995 to 2002, she was employed as a scientist at the Laboratory for Environmental Chemistry and Ecotoxicology, where she headed up the Experimental Ecotoxicology research group from 2002, obtaining the title of MER in 2005. From 2006 to 2016, she was an advisor to the President and General Secretary of EPFL. Becker has been the project manager for equal opportunities at EPFL since 2017 and has reprised her role as a delegate on the ETH Board, representing the university assemblies of ETH Zurich and of EPFL as she did from 2004 to 2006.

Marc Bürki
* 1961, Swiss
Dipl. El.-Ing.

Member of the ETH Board since 2017 and of the Audit Committee since 2018. CEO of Swissquote Holding AG since 1999 and of Swissquote Bank AG since 2002.

Marc Bürki obtained a degree in Electrical Engineering from EPFL. After gaining his initial professional experience with the European Space Agency in the Netherlands, he formed Marvel Communications S.A. in Gland in 1990, a company that specialised in the development of financial information software. Swissquote Group Holding Ltd, which specialises in online trading, was formed in 1999 and was floated on the stock market in 2000. In the same year, Swissquote Bank Ltd received a banking licence. Bürki is the CEO of both companies.
› Swissquote

Beatrice Fasana
* 1969, Swiss
Dipl. Ing. Lm

Member of the ETH Board since 2012.
Managing Director at Sandro Vanini SA since 2013.

Beatrice Fasana studied food sciences at ETH Zurich. After a traineeship at the "Nestlé Research and Development Center" in New Milford (Connecticut, USA), she worked in various leadership roles for several large food and beverage production companies in Switzerland, including Chocolat Frey and Coca-Cola. Until the end of 2012, she ran her own company BeFood Consulting SA. Since 2013 she has held the position of Managing Director at Sandro Vanini SA, a company of the Haecky Group. Fasana is also a member of the Board and Chair of the Management Committee of the University of Applied Sciences and Arts of Southern Switzerland (SUPSI, Scuola universitaria professionale della Svizzera italiana) and has been a member of the Board of Directors of Raiffeisen Bank del Basso Mendrisiotto since 2018.

Martin Vetterli
* 1957, Swiss
Prof. Dr sc.

Member of the ETH Board and of the Executive Committee since 2017. President of EPFL since 2017.

Martin Vetterli received his degree in Electrical Engineering from ETH Zurich, before then completing his Master's in Science at Stanford University and finally obtaining his doctorate at EPFL. Following professorships at Columbia University and at the University of California, Berkeley, he returned to EPFL as full professor of Communication Systems in 1995. From 2000 to 2003, he was a member of the Swiss Science Council (SSC). From 2004 to 2011, Vetterli was Vice President of EPFL, Dean of the Faculty of Computer and Communication Sciences at EPFL from 2011 to 2012. From 2013 to 2016, he was President of the Research Council of the Swiss National Science Foundation (SNSF).
› Nik Hunger / EPFL

Gian-Luca Bona
* 1957, Swiss
Prof. Dr sc. nat.

Member of the ETH Board since 2019. Representative of the research institutes on the ETH Board. Director of Empa and dual professor at ETH Zurich/EPFL since 2009.

Gian-Luca Bona studied physics at ETH Zurich, where he completed his doctorate in 1987. He then began his career at IBM, first at the IBM Research Centre in Zurich and later in the USA, where he led the Science & Technology department at the IBM Almaden Research Center in San Jose from 2004 to 2008. He was director of Tape Storage Solutions at IBM in Tucson, from 2008 to 2009, where he was responsible for the research and development of magnetic tape storage products. Bona's roles include being a member of the Board of Trustees of the Technopark Zurich and of the Innovation Park Zurich. He is a member of the Board of Directors of Comet SA and Bobst Group SA, and of the Advisory Council of the Federal Institute for Materials Research and Testing (BAM) in Berlin. He is also a member of the scientific advisory board of CSEM.
› Foto: Empa

New President of the ETH Board: Michael O. Hengartner

On 4 September 2019, the Federal Council appointed Michael O. Hengartner (* 1966) as the new President of the ETH Board. He took up his position on 1 February 2020.

Michael O. Hengartner served as Rector of the University of Zurich (UZH) from February 2014 to January 2020. From 2016 until his resignation as Rector of the UZH, he also served as President of swissuniversities. Hengartner has dual Swiss and Canadian citizenship. He grew up in Quebec City where he studied biochemistry at the Université de Laval. In 1994 he was awarded his doctorate at the Massachusetts Institute of Technology in the laboratory of Nobel Laureate H. Robert Horvitz. After that, he headed a research group at the Cold Spring Harbor Laboratory in the USA until 2001. In 2001, he was appointed to the newly established Ernst Hadorn Endowed Professorship at the Institute of Molecular Biology at the University of Zurich. From 2009 to 2014, he was Dean of the Faculty of Mathematics and Natural Sciences of the University of Zurich.

Hengartner completed an Executive MBA at IMD Lausanne and has been honoured with numerous awards for his ground-breaking research on the molecular basis of apoptosis, including the Swiss National Latsis Prize in 2006. In 2010, he received the Credit Suisse Award for Best Teaching from the University of Zurich. Hengartner was awarded an honorary doctorate from the Sorbonne University in 2016. The UZH rector received the award in recognition of his research in molecular biology and his services to society.
› UZH

Susan Gasser
* 1955, Swiss
Prof. Dr sc. nat., Dr h. c. mult.

Member of the ETH Board since 2018. Director of the Friedrich Miescher Institute for Biomedical Research from 2004 to 2019. Professor of Molecular Biology at the University of Basel since 2005.

Susan Gasser studied biology and biophysics at the University of Chicago and obtained a doctorate at the University of Basel. She was group leader at the Swiss Institute for Experimental Cancer Research (ISREC) at EPFL from 1986 until she was appointed full professor at the University of Geneva in 2001. From November 2004 until February 2019, she was Director of the Friedrich Miescher Institute for Biomedical Research (FMI), and has also been a full professor of Molecular Biology at the University of Basel since 2005. Since March 2019, she is Group Leader at the FMI. Gasser is a member of the scientific advisory board of the Max Planck Institute for Biophysical Chemistry, of the Francis Crick Institute in London and of the European Molecular Biology Laboratory (EMBL) in Heidelberg. She chairs the Equal Opportunities Commission of the Swiss National Science Foundation (SNSF).
› Nestlé Nutrition Council

Christiane Leister
* 1955, Swiss / German
Dipl.-Vw.

Member of the ETH Board since 2017. Owner and President of the Board of Directors of the Leister Group since 1993.

After graduating from Christian Albrecht University of Kiel with a degree in Economics, Christiane Leister started her career at Jungheinrich (floor-level conveyors and warehousing systems). She then headed the Controlling and Finance departments of Vereinigte Papierwerke AG and Milupa AG. She took over strategic and operational duties within the Leister family business in 1989. She has been the owner of the Leister companies since 1993, where she also acted as operations manager until 2014. During that time, Leister diversified the companies with new technologies and expanded them internationally to create the Leister Group.
› Leister AG

A complete overview of the vested interests of the members of the ETH Board can be found at www.ethboard.ch/vestedinterests.

Personnel matters

Personnel matters of the Federal Council

On 4 September 2019, the Federal Council elected Prof. Dr Michael O. Hengartner as the new President of the ETH Board, at the proposal of Guy Parmelin, WBF Chairman. The 53-year old has succeeded Fritz Schiesser who stepped down from his post at the end of April 2019. Hengartner was rector of the University of Zurich (UZH) from February 2014 to January 2020. He took up his new post on 1 February 2020.

From 2016 until his resignation as Rector of the UZH, he also served as President of swissuniversities. Hengartner has dual Swiss and Canadian citizenship. He grew up in Quebec City where he studied biochemistry at the Université de Laval. In 1994, he was awarded his doctorate at the Massachusetts Institute of Technology in the laboratory of Nobel Laureate H. Robert Horvitz. After that, he headed a research group at the Cold Spring Harbor Laboratory in the USA until 2001. In 2001, he was appointed to the newly established Ernst Hadorn Endowed Professorship at the Institute of Molecular Biology at the University of Zurich. From 2009 to 2014, he was Dean of the Faculty of Mathematics and Natural Sciences of the University of Zurich (see also p. 43).

Beth Krasna was Acting President of the ETH Board (appointed by the Federal Council on 8 March 2019). Krasna, who had been a member of the ETH Board for many years, was Vice President of the ETH Board and President of the Audit Committee at the time.

On 27 November 2019, the Federal Council elected Prof. Dr Christian Rüegg as the new Director of the PSI for four years. Dr Rüegg will take office on 1 April 2020. He is set to succeed Prof. Dr Joel Mesot, who took over the presidency of ETH Zurich on 1 January 2019. Dr Thierry Strässle, who had been the PSI chief of staff until then, was the Acting Director of the PSI.

Rüegg, 43, is from the canton of Aargau and studied physics at ETH Zurich. He obtained his doctorate at the Laboratory for Neutron Scattering of ETH Zurich and the PSI in 2005. From 2005 to 2011, he worked at the London Centre for Nanotechnology at University College London (UCL). He was a Royal Society University Research Fellow, as well as Assistant and Associate Professor at UCL. He headed the PSI's Laboratory for Neutron Scattering and Imaging in the Neutrons and Muons research area between 2011 and 2016. He took over as head of the research area in 2017 and has been a member of the PSI Directorate since 2018. He has also been a professor at the University of Geneva since 2012. Rüegg is a solid-state physicist and works on quantum phenomena in magnetism. He has been the recipient of a number of prestigious science awards for his work including the Lewy-Bertaut Prize, the Nicolas Kurze European Science Prize and an ERC grant.

On the same date, 27 November 2019, the Federal Council also renewed Prof. Dr Konrad Steffen's post as Director of WSL for a further year.

Personnel matters of the ETH Board

Appointment to the Directorate of WSL
The ETH Board appointed Dr Anna M. Hersperger as a new member of the WSL's Directorate on 1 June 2019. She comes from the canton of Lucerne, studied cultural engineering and surveying at ETH Zurich and received her doctorate from Harvard University in 2000 with a joint degree in ecology and landscape architecture.

Re-election of the ETH Appeals Commission
Within the framework of the four-yearly re-elections of the ETH Appeals Commission, as of 1 January 2020, a President and four members of the ETH Appeals Commission have been elected, or re-elected, by the ETH Board. The solicitor Barbara Wenger Gmür suceeded Prof. Hans-Jörg Peter, who held the office for eight years. The post of Vice President is still vacant as of 2020. The ETH Board would like to thank the outgoing President, the outgoing Vice President and the two outgoing members of the Appeals Commission for their great commitment in recent years.

Professorial matters
Refer to page 45 on the right for information about the appointment of professors.

Professorial matters

Appointment of professors
In 2019, the ETH Board dealt with 152 professorial matters. It appointed a total of 92 professors, 68 of whom were new members of staff and 24 were internal promotions. A total of 15 women and 44 men were appointed at ETH Zurich, as well as 14 women and 19 men at EPFL.

16 of the 34 full professor appointments were promotions of associate professors. 8 of the 19 associate professor appointments were promotions of assistant professors.

Women accounted for 32% of all appointments of new professors in 2019.

In 2019, the ETH Board appointed a female affiliated professor. Affiliated professors mainly work at a research institution in Switzerland or abroad and are only employed at a Federal Institute of Technology on a reduced employment level. They have the status of a full professor and count as that in the statistics.

In addition, the ETH Board awarded the title of professor (adjunct professor) to 3 female and 9 male scientists.

Retirements and resignations
In 2019, the ETH Board was informed of 12 retirements: 7 from ETH Zurich and 5 from EPFL. In addition, ETH Zurich and EPFL advised the ETH Board of a total of 10 resignations for other reasons.

Appointments

92

professors, 15 of whom were women and 44 men at ETH Zurich, as well as 14 women and 19 men at EPFL

Proportion of women

32%

of all appointments of new professors

The total of 92 appointments comprised:

Full professorships*

34

11 of whom were women

Associate professorships

19

3 of whom were women

Assistant professorships with tenure track

29

14 of whom were women

Assistant professorships without tenure track

10

1 of whom was a woman

* 1 of whom was a female affiliated professor

Risk situation and risk management

As the managing and supervisory body, the ETH Board sets out the risk policy for the ETH Domain. In this capacity, it sets targets for the two Federal Institutes of Technology and the research institutes. On the one hand, this serves to ensure that the tasks can be performed effectively, cost-efficiently and with foresight, and that functional and innovative capability can be maintained. On the other hand, this is to guarantee personal safety and the security of property and other assets to the greatest possible extent. The leadership of the institutions of the ETH Domain is intended to be supported by comprehensive, transparent and up-to-date risk information and risk awareness among students and staff, and the good reputation of the ETH Domain is to be safeguarded.

All the institutions of the ETH Domain have their own procedures for risk management, which serve to identify and evaluate the individual risks, as well as strategies for coping with them and for monitoring them appropriately. The risk management activities and supervision of risk management procedures are coordinated in each institution by a risk manager and / or a risk committee. Each institution keeps its own risk catalogue in which the identified risks are described in detail with an assessment on the basis of probability of occurrence and the extent of the potential damage. In addition, consideration is given to the possible effect a risk could have on reputation. The risk catalogues are updated at least once a year.

As part of their annual reporting to the ETH Board, the institutions provide information about their core risks, in particular their current status, extent and possible consequences. Core risks are those risks with potentially significant financial consequences and that have an above-average probability of occurring. They directly endanger the fulfilment of the legal duties. The reports on the core risks are then submitted to the department responsible for the ETH Domain. Moreover, the ETH Board must be informed directly by the institutions about any extraordinary changes in risk or damaging events. The individual profile, specific focus and size of each institution are reflected in its risk catalogue. Thus, the two Federal Institutes of Technology have different core risks to the four research institutes, and the assessment of the same risks can vary.

Uncertainty regarding the development of financing and the effects of an obstructive political and legal environment (relationship between Switzerland and the EU), along with violence and/or threatening behaviour towards people and cyber security remain two of the ETH Domain's most important core risks. Taking on excessive obligations, the risk of a lack of oversight of long-term financial obligations and the consequences of such, as well as the loss of management and control due to the creation of external structures represent further core risks as do dysfunction/misconduct in the area of human resources and possible infringements of scientific integrity and good academic practice.

Despite careful risk management, it cannot be ruled out that an institution may be affected by a damaging event which endangers the fulfilment of its duties enshrined in law. In this type of case, the ETH Board would submit a request to the EAER, for the attention of the Federal Council, to adapt the strategic targets or increase the federal financial contribution in accordance with Art. 30(2) of the Ordinance on Finance and Accounting of the ETH Domain following consultation with the FFA.

The insurance policies taken out by the institutions are of great importance. The institutions must take out insurance against possible losses, subsidiary to other measures, where such insurance is feasible and the funding is sufficient for it. Each institution is responsible for taking out insurance cover and administering its own insurance portfolio. When doing this, they have to take into account their specific risk situation, strive for an appropriate cost/benefit ratio and ensure compliance with the federal regulations governing public sector procurement. The insurance cover must meet the standards which are customary in the Swiss insurance market and be concluded with an insurance institution that is licensed in Switzerland. The institutions have taken out property and employers' liability insurance policies, as well as smaller insurance policies for specific risks. The real estate owned by the Federal Government is not insured, because the Confederation follows a strategy of self-insurance.

STRATEGIC OBJECTIVES

Details of the Federal Council's strategic objectives for the ETH Domain can be found on the SERI website www.sbfi.admin.ch under Higher Education/Domain of the Federal Institutes of Technology.

Strategic objective

TEACHING

The number of students and doctoral students at the two Federal Institutes of Technology continues to rise. In 2019, 33,642 students and doctoral students were enrolled at ETH Zurich and EPFL. The courses offered by the institutions undergo constant development and adaptation. One of the highlights of 2019 was the introduction of the joint Master's programme Cyber Security by the two Federal Institutes of Technology.

Excellence in research and competence-oriented education

The ETH Domain attracts a great many students and doctoral students from Switzerland and abroad. In 2019, 22,193 students and doctoral students were enrolled at ETH Zurich and 11,449 at EPFL, up 3.7% and 2.8% respectively compared with 2018. While the number of doctoral students remained constant, the number of Bachelor's and Master's students at the two Federal Institutes of Technology increased. Once again, the highest increase was in the fields of computer science and communication technologies, and this went for both Federal Institutes of Technology (+12.8% at ETH Zurich, +7.7% at EPFL). It is encouraging to note that the proportion of women has increased at Bachelor's, Master's and doctorate level. Although this increase is relatively small, it has remained constant for several years (2019: 31.7%; 2018: 31.3%; 2017: 30.6%). The increase in the number of foreign students and doctoral students is proof that the ETH Domain has international appeal. The percentage of foreign nationals among students and doctoral students in 2019 was 47.5% (2018: 46.6%). Their proportion is significantly higher at doctoral level than at Master's level and especially higher than at Bachelor's level, where 68.1% of the students are Swiss nationals (for detailed figures on students and doctoral students, see the Monitoring Table and Academic Achievement Report, p. 84 ff.).

The two Federal Institutes of Technology are continuously developing the content and form of their study programmes with a view towards reflecting strategically important areas of activity and the needs of society. In 2019, for example, ETH Zurich fundamentally revised its Bachelor's programme in Spatial Engineering in order to strengthen the interdisciplinary skills required in this area, among other things. Having introduced computer-aided thinking in all first-year Bachelor's programmes in 2018, EPFL has revised the structure of the artificial intelligence course offered for the second and third years of the Bachelor's programme and for the Master's programme, taking into account the specific features of the individual programmes. To meet society's growing need for specialists in IT security, ETH Zurich and EPFL have jointly introduced a Master's in Cyber Security (see p. 22). In the autumn semester of 2019, 16 students were enrolled on this course at ETH Zurich, and 34 students at EPFL. ETH Zurich also introduced a new Master's programme in Quantum Engineering, which had 25 students in its first semester. The Master's programme in Robotics introduced by EPFL in 2018 had 115 new students in 2019. The Master's in Data Science offered by ETH Zurich and EPFL since 2017 has remained very successful, with approximately 180 new students enrolled at both Federal Institutes of Technology in 2019 (a good 30 up on 2018). The Bachelor's programme in Human Medicine, which ETH Zurich has been offering since 2017, registered a total of 286 students in the reporting period. New ad-

missions to the Bachelor's programme in Human Medicine are limited to 100 per year. And finally, the first cohort of students graduated with a Master's in Digital Humanities at EPFL in 2019.

The lecturing staff from the PSI, WSL, Empa and Eawag offer lectures, seminars and practical work, as well as other educational opportunities in various fields. In 2019, this commitment corresponded to 18,717 teaching hours at a university in Switzerland or abroad (see Fig. 13, p. 90). In addition, the research institutes supervised 639 Bachelor's and Master's dissertations and 837 doctoral theses. Over 100 scientists at the research institutes hold an assistant professorship, a full or associate professorship or a titular professorship at one of the two Federal Institutes of Technology or at another university in Switzerland. Ten such appointments were made in 2019: six involved researchers at the PSI, two researchers at WSL and one each at Empa and Eawag.

The institutions of the ETH Domain offer various courses and activities to promote dialogue between the STEM subjects and the social sciences and humanities. For example, ETH Zurich's "Science in Perspective" programme opens up new perspectives on natural sciences and engineering and promotes critical reflection on these disciplines. As part of this programme, a symposium on science, technology and public policy was held in 2019. This focused on the role of technical universities, such as ETH Zurich and EPFL, in supporting political decision-making processes at national and international level, but also on training the next generation of specialists to meet the major challenges facing society. ETH Zurich organises 'ETH Week' every year, which forms part of its Critical Thinking Initiative. The fifth edition enabled over 200 students to explore the theme of "Rethinking Mobility" in interdisciplinary teams. EPFL's Discovery Learning Laboratories enable students to take part in international competitions and to take part in interdisciplinary projects, some of which deal with current social issues. Another notable example of the multidisciplinary pedagogical approach is the WSL Summer School on "Land System Science". In the Summer School, which is organised jointly with the University of Bern, 28 doctoral students and postdocs from all over the world and from a variety of academic disciplines learned to take a holistic view of land use change and landscape assessment in order to apply their scientific findings to the world of work in the best possible way. Finally, Eawag, in collaboration with the EPFL, ran four MOOCs on "Sanitation, Water and Solid Waste for Development" for the third year running.

Innovation and quality assurance in teaching

The academic world, which is educating the specialists of tomorrow, experiences the immediate effect of the changes in the world of work with its new technologies and increasing digitalisation. The impact of digitalisation on higher education and the development of young talent was also the topic of the "Times Higher Education World Academic Summit", which took place at ETH Zurich in September 2019 (see p. 18). The institutions of the ETH Domain are developing and promoting new forms of teaching and learning in order to tackle these challenges. The projects of the LEARN Centre at EPFL, which has been conducting translational pedagogical research to develop new teaching methods, are beginning to take shape. In addition, EPFL also launched the DRIL fund (Digital Resources for Instruction and Learning) in 2018. This is intended to support

EPFL in Lausanne is a lively place: over 120 nationalities make the campus one of the world's most cosmopolitan university sites.
› Alain Herzog/EPFL

teachers in the development of digital resources for education. A MOOC on computer-aided thinking and programmable digital notebooks (Jupyter Notebooks, an open source web app) was developed in 2019 thanks to this fund.

Regular evaluations and accreditations are carried out to ensure the quality of the courses. The results influence how training programmes are optimised. For example, EPFL has introduced a new procedure to gather feedback systematically from students and alumni on study programmes. It has also revised the guidelines for evaluating its courses. ETH Zurich has launched the "Redefine Master Admission" project. One of the aims of this project is to reformulate the objectives for admitting students onto Master's programmes. Supervising students and doctoral students and ensuring that they are satisfied is another priority of the institutions of the ETH Domain. In January 2019, for example, ETH Zurich held an international symposium on the topic of "Supervision of doctoral students". A total of 340 professors, doctoral students and administration staff as well as 40 guests from other universities in Switzerland and abroad took part. In addition, the Executive Board of ETH Zurich has decided on a course of action to develop the doctorate further. The emphasis here is on improving supervision. Similarly, WSL has drawn up new guidelines for doctoral students and supervisors, including recommendations for ensuring the quality of supervision. As part of its efforts to professionalise the supervision of doctoral students, the PSI has introduced mandatory courses for scientists with a supervising role. Empa has issued a detailed internal policy on the advancement and supervision of doctoral students, designed to improve the quality of training even further.

In addition, institutions of the ETH Domain introduced surveys in 2019 to determine the general satisfaction of their students, doctoral students and postdocs. And finally, both Federal Institutes of Technology introduced measures to cushion the impact of the increase in tuition fees. For example, ETH Zurich has decided to increase the amount of scholarships it gives to students who receive grants from cantonal authorities. EPFL, in turn, has decided to invest the money from the increase in tuition fees in teaching activities, on the one hand, and to use it for social support contributions, on the other.

Promotion of national and international exchanges

Student exchange is encouraged in order to broaden students' horizons and support platforms for sharing experience and ideas, as well as linguistic exchanges. In the 2019 spring semester, 180 ETH Zurich students studied at another university in Switzerland or abroad. This figure was 202 in the autumn semester. 392 students from EPFL opted for an exchange with another university in the spring semester, as did 437 in the autumn semester. These figures do not include the one hundred or so students who are doing their Master's project at another institution. There are also numerous exchange students who come to one of the two Federal Institutes of Technology from other Swiss or foreign universities. 467 exchange students attended Bachelor's and Master's degree courses at ETH Zurich in 2019. The corresponding figure at EPFL was 593 (see Fig. 7, p. 87).

Exchange within the ETH Domain is also encouraged through various activities. In 2019, for example, seven summer schools were jointly organised by doctoral students from ETH Zurich and EPFL. Some EPFL students are also spending a semester or doing their Master's project at ETH Zurich and vice versa. The introduction of the Master's programme Cyber Security by ETH Zurich and EPFL in the reporting period also contributed towards an increase in student exchanges, as the course includes an exchange semester between the two Federal Institutes of Technology. At European level, exchange agreements were concluded between ETH Zurich or EPFL and their principal European partners.

Strategic objective

RESEARCH

2019 was characterised by many remarkable research projects in various fields. Computer science and information technology were enhanced at the two Federal Institutes of Technology, and five of the seven additional professorships planned as part of the "Digitalisation Action Plan" have now been filled.

International leading position in research

The ETH Domain recorded many different research activities in 2019, a large proportion of which were in collaboration with other national and international institutions. In the field of neuroprostheses, EPFL researchers, working together with Italian colleagues, have developed a latest-generation robotic hand prosthesis that gives people with an amputation a real sense of touch. ETH Zurich, cooperating with an international team of researchers, has developed a bionic leg prosthesis that provides patients with neurofeedback, making leg movement much easier. Together with partners from Switzerland, the Netherlands, Israel and the UK, Empa researchers have succeeded in building a molecular bridge for electrons with unique mechanical and electronic stability. This is a major advance in the miniaturisation of electronic circuits, which could enable electronic systems to be built on a nanometre scale in the future. The research projects conducted by the PSI and ETH Zurich, which led to the development of a new material whose shape memory is activated by magnetism, should also be mentioned. The material retains a shape once it is placed in a magnetic field. This makes it particularly interesting for applications in medicine, space travel, electronics or robotics.

Other important research activities culminate in the development of new methods or help to improve existing methods. For example, researchers at ETH Zurich have developed the CRISPR/Cas method further. Dozens or even hundreds of genes can now be modified simultaneously in one cell, modifying entire gene networks in a single step. This is particularly useful in research into cell reprogramming or in the investigation of complex genetic disorders.

Biodiversity, climate change and renewable energies are also important areas of research at the ETH Domain. Following the extremely hot and dry summer of 2018, WSL researchers launched various studies on the impact of these extreme conditions on forests and the water balance. The first results were published in 2019. Eawag researchers systematically fished hundreds of Swiss rivers in September and October every year between 2013 and 2018 in order to obtain a more accurate picture of biodiversity. This project, completed in 2019, provides a new basis for protecting the ecological and genetic diversity of fish species. Researchers from PSI and WSL, together with around 600 researchers from 19 countries, are taking part in the international polar expedition MOSAiC (Multidisciplinary drifting Observatory for the Study of Arctic Climate), to understand the influence of the Arctic climate on the global climate. Among the research activities on renewable energies, it is worth mentioning the work of researchers at EPFL who have developed a system for producing large quantities of clean hydrogen as an alternative energy source by concentrating and converting sunlight into chemical energy. Researchers at ETH Zurich have developed a technology for producing CO_2-neutral fuel from air and sunlight (see p. 18). Researchers from the WSL Institute for Snow and Avalanche Research SLF and EPFL have investigated whether more electrical energy can be produced, especially in winter, by installing photovoltaic systems in the high mountain ranges in-

stead of on the Central Plateau. Together with 20 European partners, Empa has founded the SUNRISE Consortium (Solar energy for a circular economy) to develop sustainable alternatives to the fossil-based, energy-intensive production of fuels and basic products of the chemical industry. The chapter entitled "Fascination ETH Domain" (see p. 11 ff.) contains a more detailed description of other important research work in progress or completed in 2019.

The excellence of the ETH Domain's researchers is also reflected in the numerous awards and research grants they received in 2019. These include the Swiss Science Prize Marcel Benoist, which was awarded to Prof. Nicola Spaldin of ETH Zurich, and the Sanofi Institute Pasteur International Junior Award, which went to Prof. Andrea Ablasser of EPFL. Other awards included the National Latsis Prize, the Körber European Science Prize, the Rolex Award for Enterprise, the Sanofi Institute Pasteur International Junior Award, the EU Prize for Contemporary Architecture, the Young Experimental Physicist Prize of the European Physical Society, and the Sandmeyer Award of the Swiss Chemical Society.

The ETH Domain also actively participates in the National Research Programmes and the EU Framework Programmes for Research and Innovation. Three of the six National Centres of Competence in Research (NCCR) approved in 2019 are under the direction or co-direction of an institution belonging to the ETH Domain. At European level, the two Federal Institutes of Technology are actively involved in the content planning and development of the "Horizon Europe" programme, which is set to succeed Horizon 2020. Switzerland's involvement in "Horizon Europe" is crucial for maintaining the competitiveness of the institutions of the ETH Domain. The State Secretariat for Education, Research and Innovation (SERI) has mandated the Nuclear Energy and Safety research area at the PSI as the Swiss contact point for the EURATOM programme "EURAD" (European Joint Programme on Radioactive Waste Management) within the scope of Horizon 2020. Again in 2019, the institutions of the ETH Domain also received numerous ERC grants: 18 Starting Grants, 8 Advanced Grants, 6 Consolidator Grants, 11 Proof of Concept Grants, and 3 Synergy Grants.

The two Federal Institutes of Technology continue to hold top positions in the international rankings of the best universities in the world (see p. 93).

Research priorities

Numerous research activities took place within the scope of the four strategic focus areas defined by the ETH Board for the period from 2017 to 2020. These are "Personalized Health and Related Technologies" (PHRT), "Data Sciences", "Advanced Manufacturing" and "Energy". The highlights from the Strategic Focus Area PHRT are described in detail in Objective 5 (see p. 60 ff.). In the "Data Sciences" area, the projects in the Swiss Data Science Center (SDSC) are well under way, and the third call for projects was launched in 2019. All the institutions of the ETH Domain are engaged in SDSC projects. For example, researchers at the PSI and EPFL have launched the PACMAN (Particle Accelerators and Machine Learning) project with the aim of integrating machine learning into particle accelerators in order to increase their performance. Empa is collaborating with the SDSC on the Carbosense project. The purpose of this project is to simulate the propagation of CO_2 in the atmosphere, based on measurements taken by sensors distributed throughout Switzerland. WSL is participat-

The first Mars quake was recorded on the Red Planet on 6 April 2019 by the seismometer developed by ETH Zurich (shown here as a 1:2 model) (see also p. 15 ff.).

ing in two SDSC research projects: SpeedMind, which seeks to improve biodiversity models thanks to an approach based on data extraction and machine learning, and DEAPSnow, which aims to develop automated digital models for better avalanche forecasting.

Numerous activities are also under way in the area of "Advanced Manufacturing", including new projects within the scope of the support initiative ETH+ launched by the ETH Zurich Executive Board. Many of the projects in this Strategic Focus Area are carried out in collaboration with industry. One example is the joint project between Empa and G-ray, who are jointly developing a novel 3D printing system for metals. There are also numerous research projects being pursued in the energy sector (see left). The ReMaP (Renewable Management and Real-Time Control Platform) research platform, which resulted from the collaboration between ETH Zurich, the PSI, Empa and private sector enterprises, started work in 2019. There were also various events held on the theme of energy and energy consumption. At Eawag Info Day 2019, some 200 experts from the fields of practice, research and administration discussed the impact of the Swiss government's Energy Strategy 2050 on Swiss rivers and lakes.

At a higher level, all the institutions of the ETH Domain are concerned with ongoing developments in the nature of scientific cooperation and the publication of research results. For example, EPFL has stepped up its support for Open Science by launching a research fund for Open Science projects for the period from 2019 to 2021. The ETH Domain has also set up a working group with representatives from all the institutions to define the relevant aspects relating to the provision of suitable research data and free access to that data. The WSL data portal EnviDat also focuses on access to research data (see p. 26 f.).

Enhancement of computer sciences and information technology

ETH Zurich and EPFL are very active in the field of digitalisation. In addition to the numerous research projects, the two Federal Institutes of Technology are also deeply involved in the training of future specialists in the field of computer-aided science. Therefore, they launched a joint Master's programme Cyber Security in 2019 (see Objective 1, p. 48 ff.). The two Federal Institutes of Technology are implementing specific measures as part of the "Action Plan for Digitalisation" that was unveiled by the Federal Council in 2017 (see also Objective 4, p. 57 ff.). Five of the seven additional professorships for the advancement of competencies in the field of digitalisation planned within the framework of the updated total federal contribution have now been filled (three out of four at ETH Zurich and two out of three at EPFL). The ETH+ initiative also provides for additional professorships in various areas related to digitalisation. The Cyber-Defence Campus at ETH Zurich and EPFL was opened in autumn 2019. This is intended to promote cooperation between the various Swiss players in the field of cyber defence and to develop competencies in this discipline.

Academic integrity

All the institutions of the ETH Domain have taken measures to promote a culture and processes that contribute towards respecting academic integrity and offer training for researchers at all levels. The online course in "Ethics in Research", which has been mandatory for all doctoral students at the PSI since 2018 and was awarded the Comenius EduMedia Medal in 2019, is now also mandatory for all postdocs at the PSI. ETH Zurich has launched the ETHics Resource Platform, on which tools, resources and online courses on ethics are made available. In order to anchor awareness of good scientific practice more firmly at all levels, the module on "Integrity in Research" of ETH Zurich's "Compliance" e-learning platform was published in 2019. The theme and the platform were also incorporated into the onboarding process for new professors at ETH Zurich. Consulting with the other research institutes, the PSI is revising its guidelines for good scientific practice and the rules of procedure in the event of suspected breaches of integrity in research. WSL has revised the content of the events it organises on the subject of academic integrity with its employees. And Empa has intensified internal communication and exchanges on this topic with those responsible for research. All institutions of the ETH Domain consistently implement appropriate procedures in the event of suspected or proven violations of academic integrity and initiate investigations in justified cases of suspicion. The institutions are also striving for better and even more transparent internal and external communication whenever possible.

Strategic objective

RESEARCH INFRASTRUCTURES

The ETH Domain manages, develops and operates research infrastructure of national and international renown, which not only serve researchers from the ETH Domain, but which are also made available to other institutions in Switzerland and abroad, as well as to industry. Some of this research infrastructure underwent major upgrades in 2019.

Operation, further development and provision of large research infrastructure

The large-scale research facilities operated by the ETH Domain are regularly developed and upgraded to ensure that they maintain their long-term competitiveness and their benefits for the Swiss scientific community and industry. One of the major challenges is to upgrade the infrastructure without interrupting the scientists' research work. A number of large-scale research facilities at the PSI were extensively upgraded in 2019. Two experimentation stations on the ARAMIS beamline of the X-ray free-electron laser (SwissFEL) have gone into regular user operation, while preparations are under way to build a third station. In addition, the construction of the second ATHOS beamline was successfully continued on schedule, reaching the milestone of first coherent light (first lasing) in December 2019. The neutron guides of the spallation neutron source (SINQ) were also upgraded. Regular operation will resume in 2020 and will enable researchers to make new, even more precise measurements. The PSI's large-scale research facilities attracted a total of around 2,500 users in 2019, which was roughly at the level of previous years, although the SINQ was not in operation due to the "upgrade programme". About 40% of the testing time slots were used by Swiss groups, the vast majority of which came from the ETH Domain. The large-scale research facilities are overbooked by a factor of between 1.5 and 8, depending on the experimentation station. Industrial use of the Swiss Light Source (SLS) remains at a high level of around 13%. In 2019 there were also around 800 papers published as a result of access to this infrastructure.

In the NEST research and innovation building of Empa and Eawag, ETH Zurich's DFAB HOUSE unit, the world's first inhabited building that was not only digitally planned but also largely digitally constructed, was officially opened during the reporting period (see p. 14). The UMAR (Urban Mining & Recycling) unit, which was opened in 2018 and which explores the concept of closed-loop recycling in the construction sector, was chosen as one of the 20 most promising projects in the international competition "beyond bauhaus – prototyping the future". In addition, NEST also received the Building Award 2019 from the 'building foundation' in the "Research and Development" category. Another important research infrastructure at Empa is the "move" demonstration platform for sustainable mobility, which is geared towards CO_2-free mobility thanks to the use of renewable fuels like hydrogen. In 2019, move, was rolled out further and focused especially on what are known as Power-to-X processes. This involves using surplus electricity from renewable energies to generate liquid or gaseous energy carriers, such as hydrogen or methane, by electrochemical conversion, which can be stored temporarily over a prolonged period (see also p. 25). As part of a project conducted by five centres of excellence in the field of energy research, researchers from seven Swiss institutions, including ETH Zurich and Empa, have produced a White Paper on "Power-to-X" for the Swiss Federal Energy Research Commission (CORE) under the leadership of the PSI.

Finally, we should mention the 100 m² "LéXPLORE" experimental platform, which has been floating on Lake Geneva since February 2019. This joint project between Eawag, EPFL and the Universities of Geneva and Lausanne is intended to help gain a better understanding of the ecological processes of the lake and the interaction between water and the atmosphere. The platform will be accessible to all domestic and foreign researchers with an interest in this work, and the measurement results will be made available online to everyone in real time.

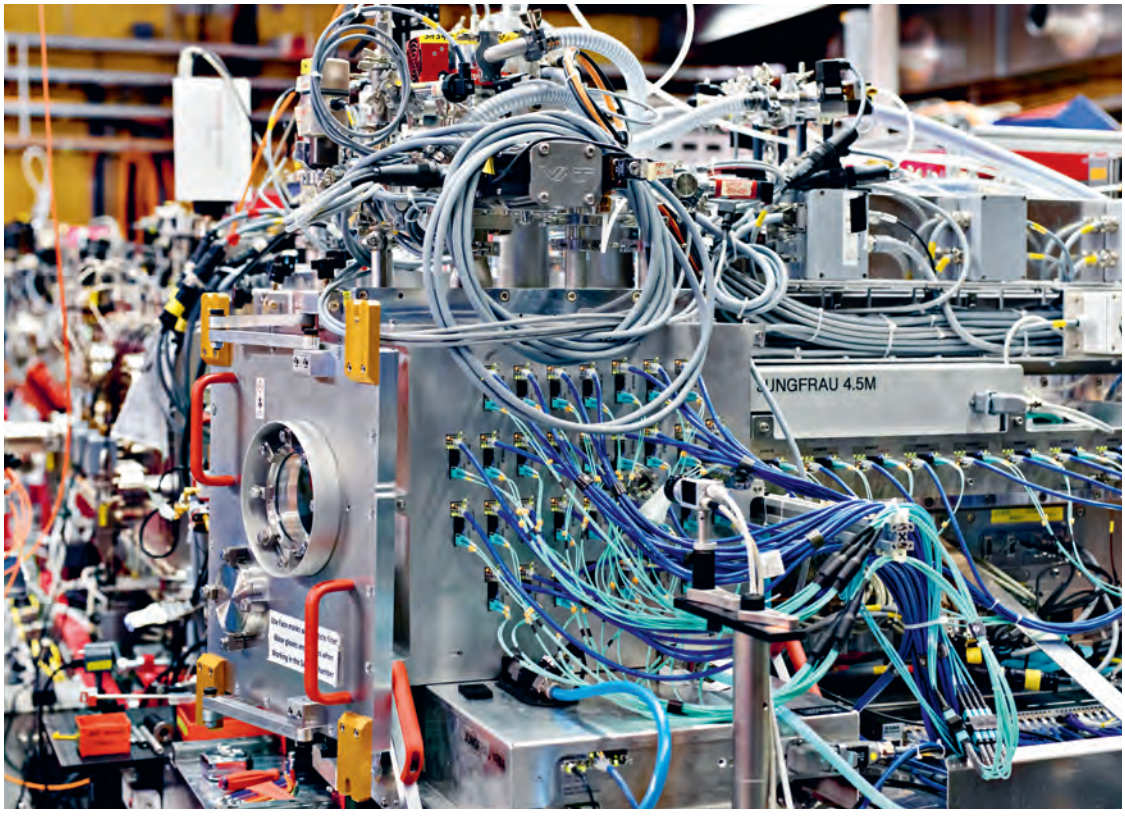
Swiss Roadmap for Research Infrastructures: Implementation of the strategic projects

The Swiss Roadmap for Research Infrastructures is the Federal Government's planning tool for investments in research infrastructure of national importance and in international infrastructure with Swiss involvement. The implementation of the Roadmap for the 2017–2020 ERI period was successfully continued in 2019.

The Sustained Scientific User Lab for Simulation-based Science at ETH Zurich's National Supercomputing Centre (CSCS) is important infrastructure for Swiss researchers, providing them with access to extremely powerful computer systems for supercomputing. This user lab is working to full capacity. The applications for computing time exceed the available capacity by a factor of two to three. The number of users and the number of projects increased by 53 or 16% between 2017 and 2019 to 1,858 users in 135 projects in 2019. Since 2019, the intensive collaboration between CSCS and the Swiss Institute of Particle Physics (CHIPP) has made it possible for the Piz Daint supercomputer to take over the analysis of part of the data generated by the experiments at CERN's Large Hadron Collider (LHC) in addition to its daily use in research.

The upgrade of the detector components of the CMS (Compact Muon Solenoid) experiment at CERN's LHC under the leadership of ETH Zurich and PSI has continued. In 2019, results were published for the first time based on the entire set of data recorded so far. Researchers from ETH Zurich and the PSI have made significant contributions towards this.

The Blue Brain Project (BBP) is aimed at digitally reconstructing and simulating the brains of rodents and ultimately that of humans. The scientific evaluation of the BBP, which took place in the last quarter of 2018, showed the importance of the pioneering idea behind this project. The application of the Big Data and Open Science concepts was particularly praised. The project provided the international community with the "Channelpedia" platform, an open database for the detailed functioning of neurons. In addition, BBP will in future participate in the NeuroTech+ initiative, which brings together researchers from the fields of neuroscience, neurotechnology and neurocomputation in order to ensure convergence between the topics of "technology-driven neuroscience" and "neurotechnology for medicine and society".



An apparently small part of the SwissFEL facility, but with the most accurate measurement sensors: the "Jungfrau" is an innovative, two-dimensional pixel detector for high-performance photon research (see also p. 23 f.).

The updated Swiss Roadmap for Research Infrastructures was also published in 2019 in light of the ERI Dispatch for 2021–2024. This included three new items of infrastructure: comprehensive upgrades of the infrastructure of the HPCN strategy (High Performance Computing and Networking Strategy) of the CSCS (HPCN-24) and SLS 2.0 at the PSI, as well as the new Catalysis Hub infrastructure.

The HPCN-24 strategy will enable the CSCS to meet the increasing demand for computing capacity thanks to the latest high-performance and energy-efficient technologies. The acquisition of a new computer system was initiated for this purpose. This system will be much more powerful than the current Piz Daint supercomputer. The design phase for the SLS 2.0 is proceeding as planned at the PSI. The upgrade of the SLS will result in a significantly higher intensity of synchrotron radiation, which will benefit imaging techniques and the investigation of very small samples. During the upgrade preparation phase, the SLS will continue to be available to domestic and foreign researchers. The Catalysis Hub will serve to create new research infrastructure at the two Federal Institutes of Technology, which will be used for research into catalyst technologies for the production of new raw materials from renewable energies (hydropower, solar energy and wind energy) as a substitute for petroleum-based raw materials. In this context, ETH Zurich and EPFL are strengthening their activities in the field of catalysis, in particular through the new National Centre of Competence in Research "Suchcat". Empa will be contributing its proven expertise in X-ray photoelectron spectroscopy at the Catalysis Hub, and will focus in particular on the integration of the new equipment at the future centre.

Involvement in international research infrastructure

The institutions of the ETH Domain are also involved in major research infrastructure and important projects at European and international level. The SERI signed the declaration of accession to the EuroHPC (European High-Performance Computing) initiative in 2019. The aim is to establish a pan-European supercomputing infrastructure and to support research and innovation activities. ETH Zurich's CSCS will represent Switzerland along with nine other countries in the Finnish LUMI (Large Unified Modern Infrastructure) consortium, which will be home to one of the three pre-exascale supercomputers of the EuroHPC initiative.

Headed by the PSI, the CHART collaboration (Swiss Center for Accelerator Research and Technology) is striving to promote the Future Circular Collider project at CERN. The project is intended to strengthen the competitiveness of Switzerland as a hub of research and industry in the field of particle accelerators and their applications. This collaboration brings together three of the institutions of the ETH Domain: the PSI, ETH Zurich and EPFL. The first phase of this project was completed in 2018. The second phase was initiated with financial support from the SERI, the ETH Board and other partner institutions.

The two Federal Institutes of Technology belong to the Swiss scientific community, which has expressed its interest in the SKA (Square Kilometre Array) project. This is a new international radio telescope network being built in South Africa and Australia to investigate the origin of the universe. This large-scale project is part of the infrastructure of the 2019 Roadmap for the 2021–2024 ERI period. Experts from EPFL will be involved in processing the large volumes of data generated by the observations.

And finally, ETH Zurich, WSL and Empa are involved in the European ICOS (Integrated Carbon Observation System) network, which aims to provide data for a better understanding of the global carbon cycle and the impact of human activities on it by means of a network of measuring stations with stringent quality requirements. The ecosystem measuring station in Davos has been awarded the highest level of certification and is now considered the official site of the network. In 2019, the ICOS published detailed data on greenhouse gases in the atmosphere, thanks in particular to measurements at the research station on the Jungfraujoch where Empa is one of the organisations involved.

Strategic objective

KNOWLEDGE AND TECHNOLOGY TRANSFER

The institutions of the ETH Domain contribute significantly to Switzerland's competitiveness. The key figures for 2019 show that there was a record number of spin-off companies founded. Networking events geared to the current needs of business and society and the expansion of continuing education programmes also promoted knowledge and technology transfer (KTT).

Enhancing Switzerland's innovative strength and competitiveness

The ETH Domain reported 224 patents, 324 licences and 329 invention and software registrations in the reporting period. 59 spin-offs were newly founded and contribute directly to transforming scientific findings into marketable products (see p. 91). In order to make this transformation successful and sharpen Switzerland's competitive edge, the institutions are engaged in an intensive exchange both with Swiss SMEs and with large corporations. In addition to the second edition of its "FORWARD" innovation forum for SMEs, EPFL organised its first "Investor Day" in 2019. 75 spin-offs were given the opportunity to introduce themselves to an audience of prospective investors. EPFL Valais Wallis also launched a pilot four-day innovation stay in Silicon Valley especially for SMEs from the Canton of Valais. At ETH Zurich, more than 80 research groups and spin-offs demonstrated their findings and services at the 2019 "Industry Day" with the State Secretary for Education, Research and Innovation in attendance. In order to offer their researchers access to the best possible KTT services, the institutions from the ETH Domain network both with Switzerland via the swiTT (Swiss Technology Transfer Association) and abroad. In the case of the latter, for example, via the "European Technology Transfer Offices Circle", in which the PSI has been represented since summer 2019 by the head of itf Technology Tranffer Office, enfuring an enhanced sharing of experience. The successful work done by the Technology Transfer Offices was illustrated in the reporting period by the "Global University Venturing Award", which ETH Zurich was the first institution outside the English-speaking world to receive. The award recognises efficient technology transfer via spin-offs, in particular.

Close contact with industry, but also with the public sector, resulted in a large number of joint projects in 2019. All told, the Institutions of the ETH Domain concluded 570 cooperation agreements with the private sector, each with a volume of over CHF 50,000, and 278 with the public sector (see Fig. 15, p. 92). Empa, for example, embarked upon a collaboration with the Swiss Roads Authority (ASTRA) and a consortium of commercial partners to improve the sensor technology for self-driving vehicles during the reporting period. At the PSI, the quality testing of components from the European Space Agency (ESA) launch vehicles was carried out in collaboration with Dassault Aviation, which contributed to the successful launch of the Ariane 5 rocket in the middle of the year. And in October, ETH Zurich celebrated the inauguration of the "Mixed Reality & Artificial Intelligence Laboratory" of the large enterprise Microsoft. Tech4Impact, EPFL's platform for social impact and sustainability, was launched in cooperation with twelve multinational companies on the topic of "Sustainable Plastics & Materials", among others.

The focus of cooperation with the public sector is on specific challenges and tasks at federal, cantonal or local authority level. In the reporting period, Eawag supported a project aimed at making wastewater treat-

ment more energy-efficient and increasing the space-saving capacity of wastewater treatment plants. Working together with the Federal Office for the Environment (FOEN), WSL has been investigating the status of and changes in biotopes of national importance for several years as part of the "Impact assessment of biotope protection in Switzerland" and published its first comprehensive report in 2019. The institutions of the ETH Domain also carry out international KTT in a systematic manner, supporting the humanitarian foreign policy objectives of the Federal Government. In January, for example, an expert from the SLF conducted an avalanche protection course for safety officers in Kazakhstan, which enabled 32 people to receive further training in natural hazard management.

Finally, innovation networks and platforms, in which the institutions of the ETH Domain participate in their capacity as centres of competence, play an important role in ensuring that the opportunities for implementing research results in various specialist areas can be used quickly and effectively. The S-WIN network, whose strategy was redefined in 2019, is devoted to the topic of "innovative wood technologies for the decarbonisation of society". In addition to WSL, Empa, the PSI, EPFL and ETH Zurich, universities of applied sciences and representatives from the timber industry are also involved in the network, which focuses on the contribution of wood use to achieving targets for lowering CO_2 emissions. The key players in the phosphorus cycle met in the summer at an expert workshop initiated by Eawag and the two Federal Institutes of Technology. With a functioning phosphorus cycle, Switzerland could play a pioneering role in the regional recycling of this vital nutrient.

National network of technology transfer centres in "Advanced Manufacturing"

The ETH Domain has a key role to play in establishing the network of technology transfer centres in the area of "Advanced Manufacturing", which is part of the Federal Government's "Digitalisation Action Plan" (see also Objective 2, p. 51 ff.). The umbrella organisation for these centres was founded at Empa in early 2019 by 22 leading Swiss organisations from science and industry. In a first step, two technology transfer centres were selected and have already started operations. They are the "Swiss m4m Center", which was set up by Empa and other partners, for the transfer of manufacturing technologies to the medical technology industry, and ANAXAM, which offers industry services in the field of materials analysis using neutron and X-ray radiation based on the expertise of PSI experts and using the PSI's large-scale research facilities.

Continuing education programme

The institutions of the ETH Domain are contributing towards the transfer of knowledge and competencies to society and the economy through their continuing education programmes. The research institutes offer courses in their fields of expertise. In 2019, for example, Eawag and the Ecotox Centre ran eight practical courses on water and water-related topics or ecotoxicology. The programme of courses run by the PSI training centre, which was awarded certification for quality compliance with ISO 29990 in 2019, is aimed at personnel from nuclear power plants and at people who work with ionising radiation in medicine or industry, for example. Some 3,300 people availed of these courses in 2019. In addition, the PSI Academy organises further training courses with a focus on interdisciplinary competencies and leadership training. In 2019, for example, WSL ran the new "Practical course on assessment of gravitational natural hazards" on behalf of the FOEN, providing almost 60 participants with specialist knowledge on assessing hazards, such as landslides or avalanches. During the reporting period, Empa reached out to civil engineers and architects with its "Urban Mining" seminar, highlighting solutions for recycling materials in the construction industry.

The two Federal Institutes of Technology offer a very large number of continuing education courses. The "School for Continuing Education", which coordinates the continuing education courses at ETH Zurich, was expanded further in 2019. In addition to six new CAS, the MAS ETH in Applied Technology also got off to a successful start. The programme offers people in the management of technology companies the opportunity to continue their education in engineering. EPFL, acting in collaboration with the University of Lausanne, now offers over 200 continuing education courses. In addition, the Extension School, which was recently launched and runs courses in the field of digital technologies, already has over 1,000 participants aged between 15 and 74. A pilot project is currently testing a comprehensive expansion of online courses specifically for companies.

Favourable conditions for KTT & enterprise

In order to promote a spirit of enterprise among their students and researchers, the institutions award targeted scholarships and fellowships or, like Empa, operate their own "business incubators". An indicator of the success of these instruments is the number of new businesses founded by the award-winning researchers. For example, the ETH Zurich's 88 Pioneer Fellows have founded 54 spin-offs in the last ten years. An important contribution to this was made by the "Innovation & Entrepreneurship Lab", which offers jobs, coaching and networking, among other things. The ieLab was visited by more than 40 national and international delegations in 2019. The Founder Fellowships that have been awarded at the PSI for the past three years have already produced the first spin-offs, in-

cluding Araris Biotech AG, which has already received CHF 2.5m in a first financing round. A series of workshops on topics such as market analysis or strategy development, which prepare prospective candidates for going through the Founder Fellowship application process, is open to all researchers at the PSI.

Certain funding programmes offered by the institutions support the development of innovative products or services in specific subject areas. In addition to the proven "Innogrants" and "Xgrants", "Ygrants" will now be awarded at EPFL. The aim is to encourage Bachelor's and Master's students to set up a company that resonates particularly positively with the environment and society. Finally, another theme focused upon is the support provided by the "ESA Business Incubation Centre Switzerland", which has become the showcase incubator of the European Space Agency (ESA) in Europe. Under the leadership of ETH Zurich and in cooperation with EPFL, Empa and the PSI, among others, eleven start-ups associated with space technologies once again received support in 2019. A particular success has been the contract awarded by the ESA for a mission to remove space debris, which was awarded to a subsidised start-up. The ETH Domain's role as an expert in space travel is also further strengthened by the coordination mandate on "Sustainable Swiss Logistics" from the Swiss Space Office of the State Secretariat for Education, Research and Innovation (SERI) to EPFL.

Strong involvement in "Switzerland Innovation"

The Swiss Innovation Park's Generation Project has achieved various successes and made progress in 2019. The ground-breaking ceremony was held for the expansion of the PARK INNOVAARE, which is located in the immediate vicinity of PSI, in November. The research institute has actively supported the search for investors and suitable companies. 14 companies have already established themselves in PARK INNOVAARE and are benefiting from the PSI's expertise. EPFL has succeeded in attracting a handful of additional companies to move into the last remaining spaces on the EPFL Innovation Park Lausanne. In coordination with the foundation and the various locations of "Switzerland Innovation", a meeting of all ten site managers was organised for the first time in Bern, where the six sites of the Western Swiss Parks Network were also represented. ETH Zurich is currently the most active stakeholder in the Zurich Innovation Park with its "Robotics & Mobility"-related activities. The university is currently developing concepts for new forms of cooperation between researchers, start-ups and industry. Empa participates in the Zurich Innovation Park and also supports the Innovation Park East in St Gallen in its application for accreditation as part of "Switzerland Innovation".

Successful spin-offs and start-ups from the ETH Domain:

Planted: it is hard to tell the difference between the plant-based alternative and real chicken meat, even when it comes to taste. Pea-protein chicken has been available from retailers since mid-January. planted.ch

The recycling industry typically sorts by colour. Thanks to *DePoly*, plastics no longer have to be separated by colour as an innovative process depolymerises them back into the most important chemicals of PET plastics.

› Markus Mallaun / ETH Board

Strategic objective

NATIONAL COOPERATION AND COORDINATION

A large number of projects and institutional cooperation arrangements are also testament in 2019 to the intensive collaboration between the institutions of the ETH Domain and with various national education and research institutions. In particular, the ETH Domain has been involved in projects of nationwide significance for shaping the Swiss higher education sector.

Cooperation within and outside the ETH Domain

The close cooperation between the institutions of the ETH Domain creates added value for all concerned by exploiting complementary aspects. The cooperation between the six institutions is particularly intensive in the strategic focus areas, within the framework of research infrastructures that is jointly used and operated, or in joint involvement in calls for proposals, for example for new National Centres of Competence in Research. There is close exchange occurring between the two Federal Institutes of Technology and the research institutions through the involvement of the research institutions in teaching and through the joint financing of professorships. Synergies are also being exploited between the research institutes in terms of subject matter and organisational aspects. For example, Eawag and WSL have been linking the fields of aquatic and terrestrial ecology since summer 2019 through a co-funded research group. The pooling of competencies is also the focus of the "Research Centre on Climate Change and Extremes" (working title), which WSL is currently planning jointly with ETH Zurich at its Davos site. The research centre is being funded by the Canton of Grisons as part of its innovation strategy. Other forms of cooperation include, for example, the Master's Programme Cyber Security run jointly by EPFL and ETH Zurich, which was successfully launched in 2019 (see also Objective 1, p. 48 ff. and p. 22), or the increased cooperation between the technology transfer offices of ETH Zurich and the PSI. PSI Founder Fellows can now also take advantage of ETH Zurich's training opportunities in the field of business enterprise for the first time. For their part, Empa and Eawag are operating a joint technology transfer office.

In addition to their internal collaboration, the six institutions are also involved in a wide range of exchanges with other Swiss educational and research institutions. There are a large number of individual projects with various partners which are being initiated directly by the researchers. At institutional level, for example, the close cooperation between EPFL and the University of Lausanne in natural sciences and humanities has been hailed a success. EPFL is currently also planning to set up chemical laboratory infrastructure on the Valais Wallis campus in the buildings of the Valais University of Applied Sciences. Successful cooperation often involves multiple partners. For example, ETH Zurich has been working closely with the University of Zurich and the cantonal centre in Strickhof for some time in agricultural science and veterinary medicine. "AgroVet Strickhof" is currently used by five professorships and four courses at the two universities. There is an even greater number of stakeholders involved in GLAMOS, the Swiss glacier monitoring network, whose management moved from ETH Zurich to WSL in 2019. In addition to ETH Zurich and the two universities of Fribourg and Zurich, the operators and funders include the FOEN, MeteoSwiss and the Academy of Sciences.

The EPFL Valais Wallis campus already boasts ten laboratories where 226 researchers and staff conduct research and work. EPFL is now planning to set up chemistry laboratory infrastructure in association with the Valais University of Applied Sciences and Art.
› EPFL

Strategic alliances

Within the scope of the strategic research alliances, the institutions of the ETH Domain ultimately also cooperate with specific research institutions of national importance funded by the Federal Government that are active in special fields. For example, some ETH Zurich research groups are actively involved in inspire AG, the competence centre for technology transfer to the mechanical, electrical and metal industries. EPFL maintains a close exchange with both the Swiss Center for Electronics and Microtechnology CSEM in Neuchâtel and the research institute Idiap, which specialises in information technology and artificial intelligence. The joint professorship of EPFL and CSEM can point towards important achievements in photovoltaic research. A record efficiency of 25% was recently achieved for a crystalline cell with a large surface area. In addition to research and KTT, there is also evidence of the good cooperation in teaching. For example, Idiap staff currently teach three courses at Bachelor's and Master's level and six courses at the EPFL doctoral school. There is another strategic alliance in place between EPFL and the Swiss Tropical and Public Health Institute, Swiss TPH, in Basel. In the reporting period, researchers from EPFL, Swiss TPH and the University of Basel launched a four-year project to explore "African Contributions to Global Health" from an historical, financial and urban planning perspective.

Implementation of the HEdA in the Swiss higher education sector

As members of swissuniversities, the two Federal Institutes of Technology are involved in the ongoing efforts on harmonisation and division of tasks within the Swiss higher education landscape. An important contribution by the ETH Domain towards helping to shape the higher education sector is its high-cost research infrastructure, which is of nationwide importance (see also Objective 3, p. 54 ff.). The institutions of the ETH Domain are also closely involved in the collaborative projects that the Federal Government is supporting with project-related contributions. The key themes are extremely varied. In the area of equal opportunities and university development, the PSI heads the project "Connecting Women's Careers in Academia and Industry", which also involves all the other institutions of the ETH Domain and the University of Zurich. The first round of the project was launched in the autumn with 35 participants from the ABB Corporate Research Center and Roche. Several projects by the two Federal Institutes of Technology are being supported in the field of digital skills. One of these is focused on university teaching staff and is being implemented as a collaboration between ETH Zurich, the Zurich University of Education and the Zurich University of the Arts (ZHdK). The universities and research institutes of the ETH Domain also have a strong presence in the area of academic information. For example, there are project-related contributions to SELVEDAS (Services for Large Volume Experiment-Data Analysis), a joint project between ETH Zurich's CSCS and the PSI. Progress was also made in the reporting period on projects that have been in the pipeline for some time. The "Swiss MOOC Service" set up by EPFL has enabled various Swiss universities to produce their own MOOCs. EPFL has been sharing its many years of experience in this area through various service agreements. "ETH goes SLSP" was launched at ETH Zurich in April. In this project the ETH library is seeking to play a pilot role and to manage the change in the library system expected as a result of the "Swiss Library Service Platform" in the most effective way possible.

Activities in the area of medicine and medical technology

Particular responsibility rests with the ETH Domain in further developing Switzerland's healthcare system. The ETH Domain's strategic focus area on "Personalized Health and Related Technologies" (SFA PHRT) is intended to boost cooperation between hospitals, universities and the institutions of the ETH Domain in the field of highly data-led, personalised medicine. The PSI hosted the first SFA PHRT PhD and Postdoc Day in May, which brought together 25 aspiring specialists. In addition, the two technology platforms for genomics and proteomics were launched in the previous year. In a pioneering project, ETH Zurich research groups have now sequenced and analysed data from 230 patient samples in three dimensions (genome, transcriptome, proteome). In August, a further technology platform was also approved at ETH Zurich, which will focus on the entire metabolism in cells and tissues (metabolomics). In terms of content, Empa scientists, among others, have been working closely with the ARTORG Center for Biomedical Engineering Research at the University of Bern within the framework of the SFA PHRT in 2019. The project, which is dedicated to microstructures in bones, is designed to apply the latest findings in microscale material characterisation to clinical practice.

In addition to the strategic focus area of PHRT, the institutions of the ETH Domain are also in close contact with a wide range of medical stakeholders through numerous other initiatives. "Zurich Heart" entered its second phase in the reporting period. Numerous publications and patents from the first phase have now been published and met with a very positive response. Besides ETH Zurich, Empa is also involved in this major project undertaken by the University Medicine Zurich partnership via several research groups and is contributing to a new generation of heart pumps. The new medical research centre of the Zurich University of Applied Sciences, "The Loop Zurich", places the focus on medical information technology. In a first for Switzerland, proton therapy was the focus of a symposium organised by the PSI this summer as part of the annual meeting of the Scientific Association of Swiss Radiation Oncology.

In the field of neurorehabilitation, EPFL was involved in the creation of the "Defitech Center for Interventional Neurotherapies – NeuroRestore", which is mainly located at the University Hospital of Vaud. The "Center for Artificial Muscles" on the EPFL's Microcity campus in Neuchâtel applied for eight patents for the minimally invasive treatment of heart failure. With the benefit of funding from the Werner Siemens Foundation, this research is being pursued in collaboration with Inselspital Bern and the Zurich University Hospital. Finally, two research projects by WSL and Eawag, which combine environmental research and medicine, also got under way in 2019. Based on fluid mechanics in nature, work is being carried out to study blood flow in main arteries in order to develop new technologies for reducing thrombosis.

The commitment of the two Federal Institutes of Technology to the training of the next generation of scientists is also important in the medical field. The Bachelor's programme in human medicine which ETH Zurich has been running since 2017, with 100 places per year, is very popular (also see Objective 1, p. 48 ff.). At EPFL, students are able to make the transition (Passerelle) from the Bachelor's degree in life sciences engineering at EPFL to the Master's programme of the medical faculties of the Universities of Lausanne and Geneva. EPFL offers four specific additional courses to prepare its students. In 2019, seven people were accepted onto the 'Passerelle' at the University of Lausanne and four onto the 'Passerelle' at the University of Geneva.

Strategic objective

INTERNATIONAL POSITIONING AND COOPERATION

In 2019, the ETH Domain continued to expand and underpin the position of its institutions as centres of global importance. This is mainly thanks to various international exchange programmes, a close-knit alliance network and global cooperation initiatives.

Attractiveness of the ETH Domain

The international exchange programmes are an essential part of the ETH Domain's attractiveness for the best foreign researchers. Their recruitment contributes significantly to the quality of the institutions. In particular, COFUND of the European Marie Skłodowska Curie Actions programme (MSCA) enables various institutions to fund promising young researchers from all over the world. For example, the programme co-finances the ETH Fellows programme at ETH Zurich, which awarded 30 scholarships in 2019. COFUND also co-finances the EuroTechPostdoc programme, thanks to which EPFL was able to take on 20 researchers, and the EPFLinnovators doctoral programme, which took on 16 new doctoral students in the reporting period. The PSI was able to hire 30 postdocs within the PSI-Fellow-II-3i programme,which is currently in its second cycle. A new COFUND support application from PSI was approved by the European Commission. Four researchers at WSL benefited from an MSCA grant in 2019. In the same year, the applications of ten further postdocs were approved at Empa in the third call of the COFUND EMPAPOSTDOC-II programme.

In addition, a follow-up COFUND project application for 50 postdocs was submitted to the Horizon 2020 programme.

There are other mobility programmes such as WSL's Visiting Fellows programme, which was more successful than ever in 2019: twelve experienced researchers from international research institutions benefited from this funding to work at WSL. The SNSF's Doc.Mobility and Early Postdoc.Mobility fellowships enable doctoral students and postdocs from Swiss institutions to carry out part of their research activities at foreign research institutions.

The institutions of the ETH Domain have also taken numerous steps to make themselves more attractive to the best foreign students. For example, the two Federal Institutes of Technology award Excellence Scholarships to outstanding Swiss and foreign Master students. In 2019, ETH Zurich awarded 51 "Excellence Scholarship & Opportunity Programme" scholarships and 35 "Master Scholarship Package" scholarships. EPFL awarded 35 "Excellence Fellowship" scholarships for the 2019 / 2020 academic year. On the occasion of its 50th anniversary, EPFL also launched the "50 Fifty Campaign" to raise funds for more Excellence Scholarships for international talent at Master's level, among other things. All the institutions of the ETH Domain participated in summer or winter schools in Switzerland and abroad, which made it possible for young researchers to receive training and further education. Finally, ETH Zurich organised a series of events in Switzerland and abroad as part of "ETH Meets You", where local experts and ETH Zurich experts from the fields of science, business and society were able to share their views on current issues and maintain dialogue with the international audience.

International cooperation

The institutions' participation in various networks and strategic alliances as well as partnerships with the international scientific community are central to the excellence of the ETH Domain.

ETH Zurich is a member of several alliances, such as the UNITECH network. This network brings together nine technical universities in Europe and international companies and runs a programme for engineering students. The UNITECH annual general meeting was held on the Hönggerberg campus in 2019. The IDEA League, of which ETH Zurich is also a member, held a summer school on the subject of "Infrastructure of Science" for its students in 2019. Both Federal Institutes of Technology are also members of CESAER, the European Network of Technical Universities, ISCN, the International Sustainable Campus Network and GULF, the Global University Leaders Forum, a platform of presidents of leading universities initiated by the World Economic Forum (WEF). The ETH Domain was well represented during the 2019 WEF, thanks in particular to ETH Zurich's RETHINKING Design pavilion, which attracted many visitors from Switzerland and further afield. The institutions of the ETH Domain also showcased a selection of research projects to a large number of visitors to the WSL Institute for Snow and Avalanche Research SLF. The NEST research and innovation building of Empa and Eawag has become a new member of the "European Network of Living Labs", a network founded by the EU Council with over 150 members, whose aim is to share ideas and provide support for individual projects. Empa and the Korea Institute of Civil Engineering and Building Technology (KICT) have signed a memorandum of understanding declaring their intention of cooperating in the area of intelligent buildings and the sustainable use of natural resources and energy.

The institutions of the ETH Domain are also involved in important projects on the international stage. For instance, WSL contributed towards the preparation of a report on the state of knowledge about landscape monitoring, which was presented to a delegation from the European Landscape Convention in Strasbourg, demonstrating its standing as an international expert. It also contributed to the publication of a new report by the Intergovernmental Panel on Climate Change (IPCC). Collaborating with the international research team "Sewage analysis CORe group Europe" (SCORE), Eawag has been involved in a project supported by the EMCDDA (European Monitoring Centre for Drugs and Drug Addiction) to detect and analyse traces of illegal drugs in sewage from major European cities for over eight years. Working in conjunction with the World Energy Council and Accenture Energy Strategy, the PSI developed the 2019 global energy scenarios, which it presented to representatives of over 140 countries at the World Energy Congress in Abu Dhabi. Empa took part in an international study which made it possible to pinpoint the origin of large quantities of chlorofluorocarbons, a group of pollutants prohibited by the Montreal Protocol.

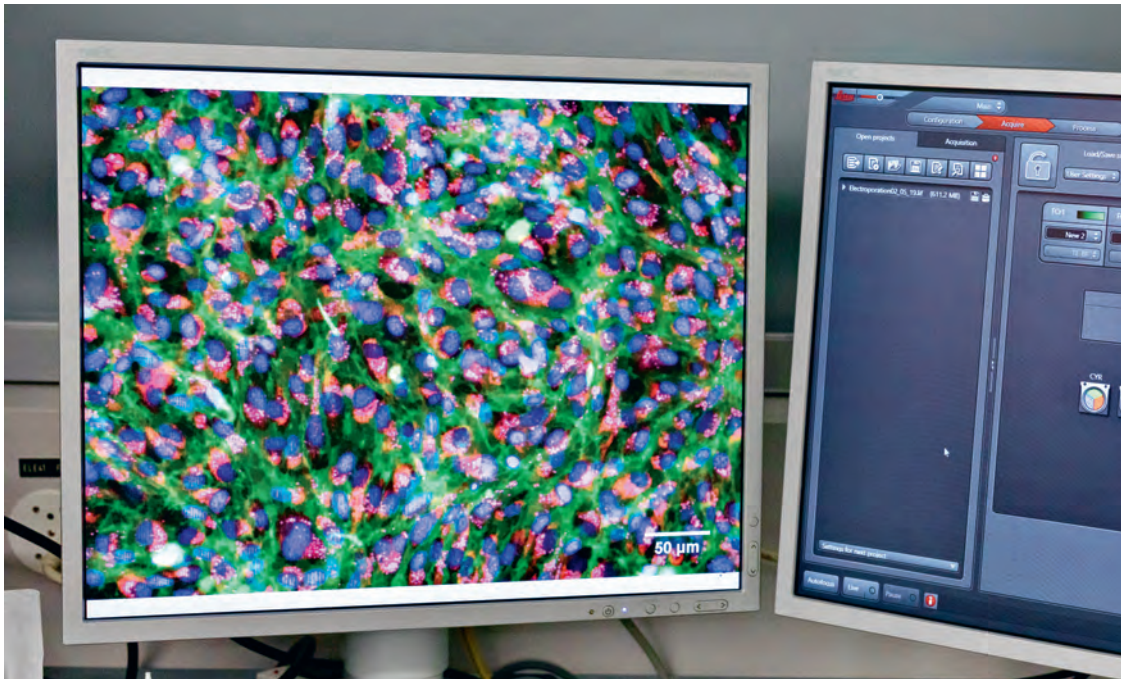
Researchers from the ETH Domain embarked upon various international cooperation initiatives. Among these was the launch of RETHINK, a think-and-do tank at ETH Zurich, which focuses on the potential of artificial intelligence for design processes in the different scientific disciplines. ETH Zurich has established academic partnerships with other international universities, such as the Multi-Scale Robotics Laboratory, which collaborates on medical robotics with the Chinese University of Hong Kong, Imperial College London and Johns Hopkins University. As part of a strategic international collaboration programme signed with the Fraunhofer Society in 2018, Empa and the Fraunhofer Institute for Silicate Research ISC in Würzburg (Germany) launched a joint research project in January 2019. This three-year project, which is part of the ICON (International Cooperation and Networking) programme, is designed to create the basis for a new generation of drive batteries for electric cars. Within the scope of projects undertaken by the Swiss Agency for Development and Cooperation, the PSI's Laboratory for Atmospheric Chemistry is collaborating with research institutions in India and China on the issue of air pollution.

The external locations of the two Federal Institutes of Technology play a major role in the international reputation of the ETH Domain. Two new programmes in the field of digital health (Future Health Technologies) and complex infrastructure systems (Future Resilient Systems II) were created at the Singapore–ETH Centre (SEC) and were approved by the National Research Foundation in Singapore. The programmes begin in spring 2020. The successful Future Cities Laboratories (FCL) programme, which is set to be completed in autumn 2020, will be replaced by the FCL Global programme, with sites in Singapore and Zurich. In the first edition of ETH Singapore Month, students from Singapore and ETH Zurich explored questions about the "Future of Urban Society". In 2019, ETH Zurich also launched the ETH Zurich Studios Bangalore (India) and West Coast (USA), with a focus on robotics, engineering, artificial intelligence and data science. The EPFL Middle East campus in Ras Al Khaimah (United Arab Emirates) celebrated its 10th anniversary. Over 100 internships, Master's and PhD theses have contributed towards numerous innovations and towards the creation of more than 130 local jobs in the energy sector. A new definitive agreement should be concluded during 2020.

Active role in the framework of the bilateral cooperation with emerging economies

ETH Zurich has been commissioned by SERI to act as the leading house for Switzerland's bilateral research cooperation with China, South Korea, Japan and the ASEAN region (excluding Singapore). In this capacity, it works in close collaboration with the swissnex network and the embassies of the partner countries, among other things to provide researchers with the financial wherewithal to establish or consolidate research partnerships. 2019 also saw the launch of ETH for Development (ETH4D). This initiative at ETH Zurich supports research projects that combine engineering, natural and social sciences in efforts to find new solutions for improving living conditions in the poorest communities, particularly in Africa. In 2019, EPFL launched an ambitious programme for scientific excellence that is designed to attract the most talented people across the continent of Africa.

There are three strands to the programme: the Junior Faculty, comprising 20 tandems between EPFL professors and young African professors; 100 doctoral scholarships for projects in Africa under the co-direction of an EPFL professor; and finally, Digital Education, the continuation of a digital education programme. Eawag is involved in the development of education and research activities in developing countries. This is done through its Partnership Programme for Developing Countries (EPP), which awards six scholarships a year to doctoral students from low or middle-income countries, giving them the opportunity to work in an Eawag department.



Excellent alternatives for animal trials: the breakthrough came with a round-robin test in various laboratories around the globe. The scientific article on this was published in the respected journal "Toxicological Sciences" in April 2019 (see also p. 32 f.).

Strategic objective

ROLE IN SOCIETY AND NATIONAL TASK

The institutions of the ETH Domain kept in dialogue with the public through a number of events. Particular importance was attached to the commitment to STEM subjects in the reporting period, with the corresponding initial and further training of teaching personnel. National tasks were also continued at a high level.

Dialogue with society

It is an important task of the institutions of the ETH Domain to explain the importance of research and technological developments in dialogue with the public, while also communicating the social responsibility borne by researchers. Scientific findings are regularly made available to the wider public by all institutions. Together with the University of Zurich, ETH Zurich opened its doors for this year's Scientifica on the theme "Science Fiction – Science Facts" and welcomed over 20,000 visitors (see also p. 18). ETH Zurich can point to a record number of visitors at the "Treffpunkt Science City" event. 23,000 people took part in the educational programme in 2019, and it was once again greatly enhanced for children and young people. The events focused, among other things, on the issue of "No Water, No Life", in which Eawag also played a major role. In 2019, EPFL also inspired some 20,000 people with a double edition of its "Scientastic" festival in Sion and Lausanne, as well as with the "Ma thèse en 180 secondes" competition. EPFL also organised various events to mark its 50th anniversary, including a public conference attended by over 3,000 people with Yuval Noah Harari, author of the best-selling "Sapiens: A Brief History of Humankind". In 2019, Empa used the Digital Day in St Gallen to demonstrate how the latest findings in materials research can be used for medical diagnosis and treatment concepts. In addition, some 20,000 interested visitors toured Empa sites during the reporting period to find out about the latest developments. The institutions collaborate with a wide variety of partners in order to reach out to the widest possible range of sections of the public and not just to address scientific communities. For example, WSL participated in "Mission B" for "Biodiversity" with all public radio and television stations in Switzerland. Radio SRF 3 broadcast live from the research institute for one day, providing a popular platform for WSL biodiversity experts. As part of the public PSI lecture series on "Experiencing Research on Site", the event on prostate cancer, in which modern techniques of early detection, diagnosis and therapy were discussed between doctors and PSI researchers, resonated particularly well in the reporting period. In addition, the PSI was involved with the Industriewelt Aargau association, a network of various museums and Aargau tourism, which aims to communicate the importance of Aargau industry and the cooperation between research and industry for the development of the canton.

The institutions of the ETH Domain bear a special responsibility when it comes to sharing their scientific findings on current issues and social challenges. The ETH Domain's research activities in the field of energy (see Objective 2, p. 51 ff.) play a particularly important role in the sustainable development of society, the economy and the environment. The institutions also undertake consulting and research projects on other current issues. During the reporting period, for example, Empa investigated the spread of microplastics in Switzerland on behalf of the Federal Office for the Environment (FOEN). Eawag and ETH Zurich, once again financed by the FOEN, carried out an extensive screening of Swiss groundwater for pesticide degradation

Teacher and soprano Matilda took a course in machine learning at the EPFL Extension School and is now also a data scientist.

Digital skills. For everyone. The EPFL Extension School offers online courses for everyone to learn digital skills. extensionschool.ch

products. In the interests of sustainable development, the institutions are also aware of the part they have to play as role models and are taking measures, for example, to reduce CO_2 emissions and energy consumption in the building and mobility sectors (see Objective 9, p. 77).

Commitment to STEM subjects

The institutions of the ETH Domain offer a wide range of programmes to nurture young people's interest in science, technology, engineering and mathematics (STEM). In Western Switzerland, EPFL organises the "Les sciences, ça m'intéresse!" programme, which once again enabled more than 12,000 children and young people to benefit from a wide range of activities related to STEM subjects in the reporting period. A special programme for young girls was expanded further in 2019. It is designed to spark the interest and creativity of girls between the ages of 7 and 15, particularly in mathematics and computer science. The institutions of the ETH Domain are pursuing a similar goal with their contributions to National Future Day. In keeping with the motto for the Future Day in 2019, for example, a particularly large number of girls at Empa were involved in this "change of sides" and were introduced to topics such as thermography or the world of molecules in workshops. ETH Zurich also organised a series of events in the reporting period which are specifically targeted at young female scientists. "goMATH" was devised by the Department of Mathematics and, among other things, included an exhibition on the theme of women in mathematics and an exchange of experience on the study of mathematics between female mathematicians, female students and pupils.

Cooperation between institutions and schools is particularly important in promoting interest in STEM subjects. The two Federal Institutes of Technology maintain close contact with secondary schools, in particular, and give presentations about their degree programmes at information days or visit school groups on site. ETH Zurich gives presentations at six to eight secondary schools each year with its "ETH on the Move" (ETH unterwegs) events, providing a realistic look at studying at the university, including insights into research and career prospects. EPFL also enables pupils to attend summer schools on topics such as robotics or material simulation. There are currently plans to broaden this programme. The PSI offers a popular field of experimentation for schools with the iLab student laboratory, which was once again used by about 200 school groups in 2019. For the first time, 18 Swiss secondary schools were awarded the STEM mark of the Swiss Academy of Sciences (SCNAT) in the iLab.

The two Federal Institutes of Technology also play an important role in the initial and further training of teachers of STEM subjects. The STEM learning centre at ETH Zurich is dedicated to optimising the school's learning opportunities in this area. Within the framework of continuing education, for example, course units are created for school groups, involving the research institutes of the ETH Domain. For example, WSL offers modules in biology such as "Climate Change – Traces in the Forest" or "What Tree Rings Tell Us", inviting teachers and their classes on an excursion to the research institute's premises.

There is currently a special focus on strengthening computer science teaching, a cause championed by the "Training and Advisory Centre for Computer Science Teaching" at ETH Zurich. For example, the centre is playing a major role in organising the "Computer Science Beaver" competition throughout Switzerland. Over 25,000 children and young people took part in the programming competition in 2019. The LEARN centre at EPFL is involved in computer science. The canton of Vaud has tasked it with preparing the secondary school curriculum in computer science. Initial feedback from teachers has been very positive. As part of the SERI-funded "DUAL-T" initiative (technologies for vocational education and training), EPFL, acting as leading house, is also working to strengthen its capacities in the field of learning technologies, as well as vocational education and training research. The key question here is how the digital revolution is changing the Swiss VET system and learning activities.

New, innovative teaching and learning methods are also the subject of various prizes and competitions which were launched in the reporting period. On the eve of the 200th birthday of the Zurich politician and business leader Alfred Escher, ETH Zurich awarded the Alfred Escher Prize for innovative pupils and students for the first time in February. The winners were two projects that motivate students to learn through games. In addition, ETH Zurich is on the jury of the new fund to support innovative teaching projects at secondary schools, which was launched by the Education Department of the Canton of Zurich. The LEARN AWARD for innovative teaching projects at secondary schools was announced at EPFL's "Journée de l'éducation". Secondary school teachers from all over Switzerland attended the event to mark the 50th anniversary of the university.

National tasks

Finally, the institutions of the ETH Domain perform a wide range of national tasks on behalf of policy-makers and in the interests of society. These include research-based services or the operation of facilities that are unique in Switzerland, such as the PSI Centre for Proton Therapy. They also include the long-term preservation of public goods, such as collections of scientific merit. In the latter respect, the ETH Library was able to announce the completion of a major digitalisation project in the reporting period. The 4,300 or so books, newspaper articles and typescripts in Thomas Mann's estate library have been fully transcribed and digitally indexed. The ETH Library is currently devoting itself to a three-year project to index administrative documents belonging to ETH Zurich and the ETH Board that are not already listed in the archive database. In the environmental sphere, the institutions provide several specific services to benefit the country. Empa operates the National Air Pollution Monitoring Network NABEL together with the FOEN. Its fairly new Beromünster measuring station was included in the "Global Atmosphere Watch" programme in 2019 due to its excellent data quality and availability. It facilitates the monitoring of both largely unpolluted air masses and emission mixtures emanating from various sources in the Central Plateau. By doing so, Switzerland is making an important contribution to the international study of air pollutants.

Eawag and EPFL operate the Swiss Centre for Applied Ecotoxicology. In the reporting period, the centre demonstrated what effect pesticides have on microorganisms in sediments and developed sediment quality criteria from these findings. The Ecotox Centre also played a major part in the ISO standardisation of three biological test methods for detecting oestrogenic substances in 2019. In the area of natural hazards, ETH Zurich operates the Swiss Seismological Service (SED) as a federal specialist agency. The SED published a study in 2019 in the eminent journal "Nature" on a new technique to predict whether an earthquake is likely to be followed by another, larger one. WSL's area of expertise includes avalanche warnings for Switzerland. The SLF published an event analysis in 2019 of the exceptionally stressful avalanche situation in January of the previous year. Despite 150 avalanches resulting in damage, there were no fatalities in residential communities and in secure areas. The analysis arrives at the conclusion that the measures introduced after the winter of 1999, when there was a spate of severe avalanches, had proved to be effective.

Strategic objective

SOURCES OF FINANCING AND ALLOCATION OF FUNDS

The volume of third-party funded projects was again up on the previous year. The ETH Domain uses existing third-party funding reserves to create new professorships or strategic research initiatives inpromising areas.

The total funding of the ETH Domain in the 2019 reporting year amounted to CHF 3,579m, slightly up on the previous year's level (CHF 3,571m). Compared with 2018, there was a slight shift in the proportion of the total volume accounted for by the total federal contribution (2019: 72%; 2018: 71%). The share of third-party funding, measured in terms of operating revenue, accounts for 28% (2018: 29%).

In 2019, federal funds from the total federal contribution (expenditure ceiling credit perspective) was up again on 2018: +CHF 50m (+2%). There was a decrease in donations within third-party funds. They more than compensated for the increase in the volume of third-party funded projects and ultimately led to a slightly lower proportion of third-party funds in the overall total.

The ETH Domain exploits synergies. Synergy effects were achieved in 2019, for example, by promoting joint initiatives and projects such as the Strategic Focus Areas (SFA). The cross-divisonal use of technologies (including high-performance computers, laboratories, scientific and administrative infrastructure) also contributes to increasing efficiency in the ETH Domain.

Total federal contribution
It is expected that 99% of the maximum CHF 10,337.8m expenditure ceiling for the ETH Domain approved by the Federal Parliament will be utilised. The total of the approved credits for the 2017–2020 period amounts to CHF 10,239.0m. The average annual growth is +1.4% This is slightly below the projected average growth rate of +1.9% for the current ERI period of 2017–2020.

Allocation of funds based on relevant criteria
The ETH Board allocates federal funds (total federal contribution) in accordance with Section 33a of the ETH Act. This is based on its target agreements with the two Federal Institutes of Technology and the four research institutions. The allocation of funding within the ETH Domain is governed by Section 12(2) of the Ordinance for the ETH Domain.

The Federal Council's strategic objectives for the ETH Domain, which are tailored to the 2017–2020 expenditure ceiling, form the basis for the ETH Board's four-year target agreements with the institutions. The annual allocations of funding to the institutions are adjusted in line with the annual budgetary credits decided on by Parliament. In making these decisions, the ETH Board draws upon the budget requests of the institutions and the assessment of their performance.

In 2019, there was a total of CHF 2,581.2m available from the credits offset against the expenditure ceiling (2018: CHF 2,530.9m).

Fig. 1: Expenditure ceiling for the ETH Domain in the ERI period from 2017–2020

CHF millions	2016	2017	2018	2019	2020	2017–2020
ERI Dispatch of 24 February 2016 (16.025)	**2,453.8**	**2,489.1**	**2,524.3**	**2,561.6**	**2,602.8**	**10,177.8**
FedD 4 expenditure ceiling ETH Domain – increase		**40.0**	**40.0**	**40.0**	**40.0**	**160.0**
Expenditure ceiling of the ETH Domain 2017–2020 FD of 16 September 2016	**2,453.8**	**2,529.1**	**2,564.3**	**2,601.6**	**2,642.8**	**10,337.8**
Nominal growth in CHF		75.3	35.2	37.3	41.2	
Nominal growth in %		3.1	1.4	1.5	1.6	
Ø annual growth 2017–2020 (based on 2016 budget) in %						1.9

Fig. 2: Credits taking into account the expenditure ceiling of the ETH Domain

CHF millions	2016	2017	2018	2019	2020	2017–2020
A231.0181 Federal financial contribution	2,288.7	2,377.9	2,356.7	2,372.6	2,415.1	9,522.3
A202.0134 Investment credit for ETH Domain constructions	165.1	152.9	174.2	208.5	181.0	716.7
Total credits, taking into account the expenditure ceiling	**2,453.8**	**2,530.8**	**2,530.9**	**2,581.2**	**2,596.1**	**10,239.0**
Nominal growth in CHF		77.0	0.1	50.3	15.0	
Nominal growth in %		3.1	0.0	2.0	0.6	
Ø annual growth 2017–2020 (based on 2016 budget) in %						1.4
Expected consumption of credits, taking into account the expenditure ceiling, in %						99.0

Fig. 3: Allocation of funding to the institutions of the ETH Domain (after taking into account the reallocation in credit/funds within 2019)

						Δ 2018 / 2019	
CHF millions	2015	2016	2017	2018	2019	abs.	%
ETH Domain [1, 2, 9, 10]	**2,417.9**	**2,453.8**	**2,530.8**	**2,530.9**	**2,581.2**	**50.3**	**2.0**
ETH Zurich [3, 6]	1,224.0	1,247.2	1,297.4	1,300.5	1,298.1	−2.4	−0.2
EPFL [4]	618.1	640.3	666.2	664.9	664.8	−0.1	−0.0
PSI [5, 8]	324.0	305.4	294.3	307.3	309.8	2.5	0.8
WSL	55.7	55.9	58.7	58.3	57.7	−0.6	−1.0
Empa [6]	106.7	110.7	114.7	105.2	115.7	10.4	9.9
Eawag	58.6	59.1	61.5	61.5	60.5	−0.9	−1.5
ETH Board [7]	30.7	35.1	38.2	33.2	74.7	41.5	125.2

Additional information on the budget/financial statements 2019:

1 Total allocation of funds in 2019

2 Annual tranches in accordance with the approved expenditure ceiling for 2017–2020 (credits taking into account the expenditure ceiling of the ETH Domain): annual tranche for 2019: CHF 2,601.6m / federal decree (FedD) on the budget according to FedD Ia for 2019: CHF 2,581.2m

3 Including sustained scientific user lab for simulation-based science at the CSCS: CHF 22.9m, start-up funding President: CHF 3.0m, additional costs: serious earthquake measurement network: CHF 0.8m

4 Including the neuro information technology project, the Blue Brain Project: CHF 20.8m, start-up funding President: CHF 3.0m

5 Including ATHOS/SwissFEL: CHF 16.0m, Action Plan Energy PSI: CHF 3.0m

6 Including real estate portfolio adjustment: 2019: ETH Zurich CHF 8.5m, Empa CHF 1.5m

7 Including strategic projects, financing the dismantling of accelerator systems at the PSI (CHF 11.0m), contributions towards the ETH Domain's pension fund with PUBLICA (degree of cover provided CHF 3.5m) as well as funds received in 2019, which will be used to cover the expenditure surplus budget 2020

8 Including special funds (CHF 6.9m)

9 Including strategic focus areas (Personalized Health and Related Technologies, Data Science, Advanced Manufacturing) (total: CHF 24.4m)

10 Including research infrastructure (upgrade to CMS detectors at CERN, Swiss Plasma Center) (total: CHF 5.5m)

The ETH Board allocated the funds for the base budget as follows (2019: total of CHF 2,386.1m):

- ETH Zurich CHF 1,243.0m
- EPFL CHF 634.0m
- PSI CHF 286.5m
- WSL CHF 57.2m
- Empa CHF 104.5m
- Eawag CHF 60.8m

Funding for the strategic projects of the ETH Domain:

- Research infrastructure/ large-scale research projects: CHF 65.2m
- Strategic focus areas (SFA): CHF 24.4m
- Digitalisation in the ETH Domain (including the decision by the ETH Board to increase funding): CHF 13.8m
- Incentive and initial funding, other central and various expenses, as well as special funds: CHF 46.8m

Funding for the ETH Board:

- Own consumption by the Administration of the ETH Board and Appeals Commission: CHF 15.0m
- Pursuant to the allocation of funding decision taken by the ETH Board, the +CHF 30.0m increase in funding by the Federal Assembly in accordance with federal decree (FedD) Ia will not be applied or used in 2020 and not in 2019 (overbudgeting of the 2020 budget by CHF 20.8m to date). At the end of 2019, they were reported as reserves in the ETH Board's accounts.

Expansion of the funding base

The most important purpose of Objective 8 is the continuous broadening of the ETH Domain's funding base. A primary indicator is the measurement of the share of third-party funding [1] in the total financing of the ETH Domain. However, the absolute development of funds and, in particular, developments in the award of grants are also important criteria for assessing the attainment of objectives.

Development of third-party funds

The total operating third-party funds amounted to CHF 1,010m. The budgeted value was exceeded (2019 budget: CHF 1,007.4m), whereas it fell short of the previous year's value (2018: CHF 1,043m).

Total federal research contributions (SNSF, Innosuisse, special federal funding for applied research and EU FP) as part of third-party funding amounted to CHF 543m, exceeding the previous year's high figure (2018: CHF 533m).

The value forecast for 2019 had been CHF 553m. Research contributions from cooperation with the private sector and other project-oriented research (2019: CHF 219m) exceeded the budgeted value (2019 budget: CHF 203m) and the previous year's value (2018: CHF 207m). The total of other third-party funds (donations and various sources of revenue) was below expectations for 2019, amounting to CHF 200m (2019 budget: CHF 210m; 2018: CHF 263m).

Operating third-party funding, measured by operating revenue, was 28% in the current year (2018: 29%). Overall, the trend in third-party funds in 2019 continued to show a positive picture, apart from donations. This positive trend is also underlined by the development of absolute values compared to 2018. This can be seen from the increase in research contributions from the federal government and the private sector.

When making an overall assessment of the development of third-party funding, it is also necessary to take balance sheet transactions into account, in particular the development of dedicated third-party funds from contracts recognised in accordance with IPSAS 23. If the volume increases compared to the previous year, this could be a positive indication of the required expansion of the funding base. The dedicated third-party funds entered in the balance sheet rose in the current year (2019: CHF 1,555m; 2018: CHF 1,510m). With regard to research contributions, this higher volume will have an effect on the corresponding additional income.

A further significant criterion for assessing whether Objective 8 has been achieved is the development of funding (SNSF, Innosuisse and EU FP). The volume decreased compared with 2018 (2019: CHF 443m; 2018: CHF 512m; 2017: CHF 422m). This is largely due to the decline in the number of competitively recruited research projects of the EU FP.

The indirect costs from third-party funded projects – unless they are research contributions from the federal government or the EU – are offset in such a way that the base budget is not affected by these costs; therefore, they are not cross-subsidised via funds from the federal financial contribution.

Maintaining teaching and research freedom

The two Federal Institutes of Technology and the four research institutes ensure independently that the research results of third party-funded projects can be published. The units of the ETH Domain guarantee un-

[1] Second-party and third-party funding are the categories used prior to the conversion to IPSAS (International Public Sector Accounting Standards). Since 2015, these have been part of the category Research contributions (Federal Government: SNSF, Innosuisse, special federal funding of applied research, EU FP), research mandates and scientific services. The former third-party funding includes industry-oriented research (private sector), the remaining project-oriented third-party funding (including cantons, municipalities, international organisations), donations and bequests, and other revenue streams (see Fig. 4, p. 72).

restricted freedom of teaching and research. The publication freedom of and with supported people and projects is also guaranteed at all times. The contracts contain a provision to that effect. The freedoms are also ensured contractually in the area of research cooperation. In addition, the handling of donations is regulated explicitly by the code of conduct.

Increase in efficiency and use of synergy effects
Joint initiatives and the joint use of research infrastructures result in significant synergy effects in the ETH Domain. This includes the shared reporting platform on SAP FC. In order to ensure that everything runs efficiently, the pooling of liquidity for the entire ETH Domain is also handled by ETH Zurich. ETH Zurich achieves the same internal effect with the new resource and finance platform. Efforts to create synergies within the ETH Domain include a number of joint research platforms or programmes supported by several institutions of the ETH Domain to allow full networking and use of complementary research expertise.

For example, the Swiss Data Science Center (SDSC) of EPFL and ETH Zurich, the Energy System Integration (ESI) platform of the PSI, Empa, EPFL and ETH Zurich or the shared libraries. The joint EPFL and Empa Laboratory of Materials for Renewable Energy (LMER) exists at the EPFL Valais Wallis site.

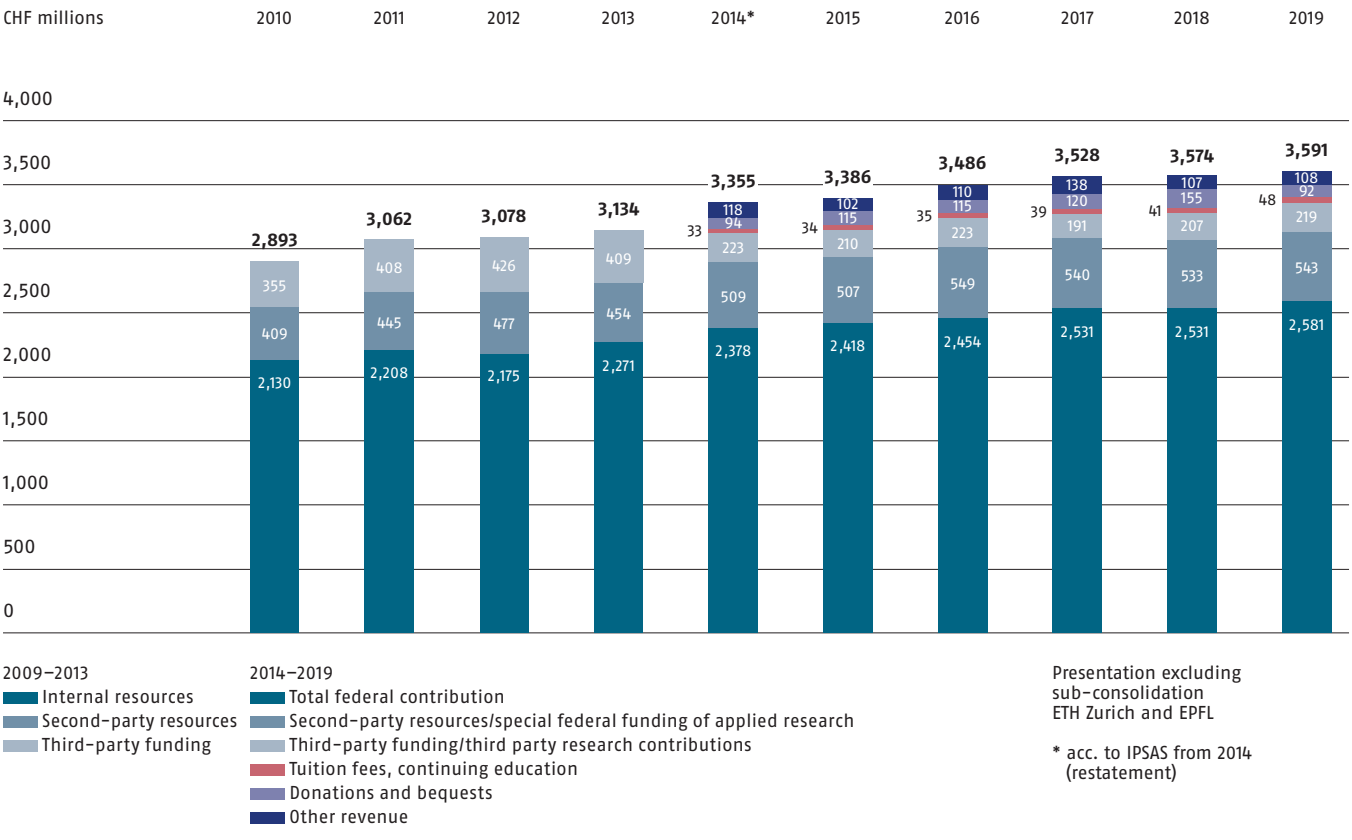
Dismantling and disposal of the PSI accelerator plants
Radioactive waste arises from the use of nuclear energy or ionising radiation applications in medicine, industry and research (MIR waste). The Nuclear Energy Act and the Radiation Protection Act set out the requirements for disposal.

The financing of the provision of a total of CHF 544m for the decommissioning of the accelerator facilities at the PSI is to be financed through annual savings amounts debited to the federal financial contribution credit.

By the end of 2019, the savings amounted to a total of CHF 31m (savings amount in 2019: CHF 11m). The PSI has so far used around CHF 4m (2019: CHF 2.6m) of the accrued savings for initial measures in connection with the dismantling.

Management of core risks
To that end, we refer to the report on the risk situation and risk management, p. 46.

Fig. 4: Development of the sources of financing



Strategic objective

REAL ESTATE MANAGEMENT

Visible progress is being made on major projects. Work on the buildings required for teaching and research at ETH Zurich in Zurich Zentrum and Basel campuses and at Eawag in Dübendorf is well advanced. New proposals and control tools in real estate management are being used to boost professionalism, simplify collaboration and increase the usefulness of buildings for teaching and research.

Strategy and long-term portfolio development
In 2019, federal guidelines were put into effect as part of the climate package and the "structural measures" that have an influence on the long-term planning of the real estate portfolios of the six institutions. Looking ahead to the forthcoming performance period from 2021 to 2024, initial considerations, documents and discussions were initiated in 2019 in order to develop long-term portfolio planning on the basis of the institutions' academic strategy process. This will result in the "spatial and financial master plans" (SFMP). These will ensure the preservation of values and function as well as the timely provision of necessary new infrastructure for teaching and research, as well as their financing.

Due to its function as a role model, the Federal Government has also set high sustainability targets for the ETH Domain. As part of the structural reforms, the Federal Council instructed its building and real estate bodies to review the relevant rules and standards. ETH Zurich has had its own real estate strategy since the end of 2019. The principles contained therein are based on the academic strategy process and concern the profitability and sustainability of real estate management. The ETH+ initiative launched by the Executive Board with the aim of maintaining ETH Zurich's leading position entails a corresponding need for consolidated space. Due to the steady growth, ETH Zurich has rented space in the OCTAVO and Andreasturm buildings for future accommodation in Zurich-Oerlikon in order to be able to cover part of the short to medium-term need for replacement and additional space in good time. The adaptation of the special building documents for the Hönggerberg campus is on course. At the end of October 2019, as part of the partial revision of the cantonal outline plan, the Cantonal Council also approved the territory planning for the Hönggerberg campus. ETH Zurich has an ETH Hönggerberg 2040 master plan and an ETH Zurich energy master plan.

EPFL's real estate strategy preserves the value of the architectural and cultural heritage and ensures its development in line with the needs of the users and taking dedicated funds into account. The growing need for modern infrastructure for the Physics and Chemistry Instituts necessitates the construction of a new building. In an exchange with the canton of Vaud and the municipality of Lausanne, it was established that a northern extension of the space would have to be made available for the EPFL and the University of Lausanne. At the same time, the two universities jointly initiated the preparation of a master plan for their universities, which was completed at the end of 2019 and is due for adoption at the beginning of 2020. Future developments such as the Alpole Campus Valais Wallis in Sion and the Smart Living Lab in Fribourg are part of the strategy.

The PSI continued the work for the realisation of the PARK INNOVAARE (start of construction in November 2019), the spatial consolidation of individual areas,

On the ground floor of DFAB HOUSE 15 bespoke, digitally fabricated concrete mullions line the façade. The double-curved, robotically manufactured wall supports the load of the ceiling, which was created in a 3D printing process.
› Roman Keller

the clearance of areas and further conversions and renovations. Due to the shortage of space, WSL is planning additional jobs in connection with energy-related renovations. The strategic planning of the research topics relevant to Empa-Eawag's research campus has shown that modern laboratories and cleanrooms will increasingly be required in the future. In addition, the interaction and interdisciplinarity between the research teams is to be promoted by a suitable type of building.

Various real estate deals were concluded in the ETH Domain in 2019. For example, the former SLF institute building on the Weissfluhjoch was sold to Davos Klosters Bergbahnen AG. The operation of measuring stations as well as snow and avalanche research are still possible. Furthermore, the property at Rue Jaquet-Droz 7 in Neuchâtel was sold to the Canton of Neuchâtel. The latter is expected to use the site as part of the Swiss Innovation Park for Microtechnology.

Real estate management in figures

The purchase value of the ETH Domain's real estate portfolio at the end of 2019 amounted to CHF 7.92bn. In terms of value, this represents about one third of the entire real estate portfolio of the Federal Government. The book value is around CHF 4.09bn. The ETH Domain uses around 390 buildings on 120 plots of land. The main usable area reported at the end of 2019, which covers 986,300 m^2, is up 1.40% on 2018.

The mix of space (see Fig. 28, p. 98) with state-owned buildings for own use and use by others, and buildings rented by third parties (in m^2 of main usable area since 2010), shows how some of the growth in recent years could only be covered using additional leased space. The growth in leased space is attributable to the changes in the statistical allocation of space after 2013. Without this effect, there would be a steady decrease in the leased space.

Ongoing and completed projects of 2019

Due to the increase in the number of professorships at both universities and the need for state-of-the-art spatial infrastructure, demand for new buildings, extensions and repairs remains high. Refurbishments are being carried out with a view towards improving use, energy status, the indoor climate, disabled access, fire protection, earthquake safety and operating costs.

In addition to the above-mentioned leasing in Zurich-Oerlikon, ETH Zurich was able to press ahead with the creation of the new GLC research building with laboratory and office space at Gloriastrasse on the Zentrum campus for the D-HEST and D-ITET departments. In addition, the refurbishment of the main building HG and the refurbishment and extension of the ML/FHK Machinery Laboratory progressed as planned. On the Hönggerberg campus, work began on the overall refurbishment and expansion of the HIF building, and the development of the new HPQ physics building was developed further up to the preliminary project design stage. After successful complete refurbishment, the HPM building boasting new laboratories and work areas will be available again for the Department of Biology and Scope M. The new BSS building in Basel is under way, and the topping-out ceremony is scheduled for the second quarter of 2020. The preliminary studies for the Advanced Science Building began at EPFL. The visitor forum at the PSI was refurbished, the planning and implementation of the hall extension WLHA and the construction of the new outdoor measuring building WMGA got under way. The basic work for the planning of SLS 2.0 also began. At the SLF in Davos, the oil heating system was replaced by an environmentally friendly groundwater heat pump, and the extension of building D (replacement new building) was continued. Preparations were made for the replacement of the WSL workshop building in Birmensdorf. In Dübendorf and St Gallen, Empa continued several re-

novations and refurbishments; Eawag began with the construction of the new FLUX building for teaching and research on the Dübendorf campus. In order to implement the Empa–Eawag research campus/energy area master plan in Dübendorf, a TU competition with dialogue took place for the first phase of building and open space development.

Investments and source of funds in 2019

The investment credit for buildings in the ETH Domain in 2019 was CHF 218.6m following a necessary credit reallocation in the financial contribution of CHF 7.25m (3.2%) and the release of dedicated reserves of CHF 10m in accordance with the Federal Financial Budget Act (Art. 32a FBA) for the BSS new building project in Basel. This meant that it was above the previous year's value (CHF 134.2m). 42.7% of the investments were accounted for by new buildings, and 57.3% by preserving value and functionality. No third-party funds were used for federal real estate. CHF 96.3m was used from the Federal Government's financial contributions for investments in user-specific operating facilities which will be owned by the institutions. These investments were supplemented by third-party funding of CHF 16.1m. The volume of construction authorised by the ETH Domain in 2019 amounted to CHF 332m (see Fig. 25, p. 97). The ETH Domain received an accommodation loan of CHF 243.8m in 2019 for the calculated rent on the state-owned real estate. The Source of Funds chart (see Fig. 25, p. 97) shows the sources of funds for the buildings in the ETH Domain since 2010. The annual fluctuations are dependent on the type of grant and the scope of the current construction projects. The investor-financed PARK INNOVAARE project at the PSI was launched in 2019. The investment volume from the investor for the first phase is approximately CHF 160m.

2020 construction programme: Major ETH Domain projects

In the case of planned new-build projects, the ETH Domain applies for the contingent credit with its annual construction programmes. These were approved by the Federal parliament with federal decree Ia regarding the 2020 estimate. The 2020 construction programme for a total of CHF 211.2m (total credit), proposed by the ETH Board in December 2019 and approved by Parliament on 12 December 2019, includes both of the following major projects: an application has been made for CHF 15.2m for the realisation of the Zurich Zentrum cooling grid – the centrepiece of the Energy ETH Zentrum master plan. This will guarantee the stable and reliable refrigeration supply required for the operation of the research infrastructure and increase the sustainability of the energy supply. In the longer term, the use of water from the lake is being considered, and this is being factored into planning. Preparations are under way for the possible use of water from the lake in the future. Overall, the network will increase sustainability considerably, with applications for CHF 15.2m submitted. The new construction of the Discovery Learning Lab EL (DLL EL) in Lausanne Ecublens for CHF 15.0m is the second major construction project. It is working infrastructure designed to facilitate the development of innovative educational projects, teaching and learning methods and their practical implementation. The Discovery Learning Programme initiated by EPFL will also be made available to the School of Engineering due to its proven success. A credit line of CHF 181.0m has been requested for 2020. Credit lines make it possible to carry out construction projects costing up to CHF 10m, and to plan projects over CHF 10m.

Maintaining value and functionality

The ETH Board is legally obliged to maintain the value and functionality of the properties of the ETH Domain, and this is in the interests of the Federal Government as the owner of the real estate and of the entire ETH Domain as its user. The state of the individual properties will be determined applying standard methodology, will be accumulated at portfolio level and will be compared against multi-year trends. Despite the advanced age of some of the buildings and their intensive use, the state value of around 83% determined in 2019 remains constantly high in relation to the new value (see Fig. 26, p. 97). The refurbishment work on the

Strategic real estate management in the ETH Domain

Efficient building infrastructure is a central requirement for enabling both Federal Institutes of Technology and the four research institutes to achieve their targets in teaching and research and to fulfil their performance mandate and meet the required quality standards. The real estate of the ETH Domain is owned by the Federal Government. The investment credit for construction is separated annually in the budget for a specific purpose. It appears in the state accounts under the Federal Department of Finance (Federal Office for Buildings and Logistics, FBL). As one of the Federal Government's three building and real estate authorities, the ETH Board assumes the ownership role in trust. It is responsible for the real estate portfolio of the ETH Domain and consults the institutions on strategic real estate management in order to ensure the functionality of the real estate portfolio in the medium and long term and to preserve its cultural value. Needs-based planning, and the timely realisation of new construction projects, conversions and refurbishments, are at the heart of its remit. The preservation of value and functionality is the result of needs-based planning, geared – also in the interests of the owner – towards cost/benefit considerations, as well as corresponding controlling at ETH Board level. The owner is kept abreast of this by way of reports from the ETH Board. The ETH Domain is committed to the sustainable development of its real estate portfolio and to sustainable real estate management. It does so in compliance with the Federal Council mandate under Art. 73 of the Federal Constitution, as well as the government's strategy for sustainability.

historical building stock, in particular, is considerable in some cases, leading to challenging construction projects. Renovation projects in excess of CHF 369m are currently included in the 2020–2023 real estate investment plan. They triggered an investment volume of some CHF 125m in 2019. In addition, ongoing maintenance work amounting to some CHF 50m was funded from the state financial contribution. Consequently, the ETH Domain demonstrated in 2019 that it is using the building stock provided by the Federal Government responsibly and sustainably.

Coordination tasks

In 2019, the Real Estate department of the ETH Board coordinated the interests of the government agencies and institutions of the ETH Domain in the development of norms, standards and guidelines for the planning, realisation and operation of real estate. Adequate involvement of the institutions was ensured in issues such as procurement and contracts, the protection of critical infrastructures and application of the Building Information Modeling (BIM) method. Further priorities in 2019 were regarding sustainability issues, such as the Federal Government's building culture strategy, the revision of the landscape concept, the implementation of mandates from the federal administration's climate package or the continuation of the "Exemplary in Energy" efficiency initiative. The ETH Board is a member of the Commission of the Office for University Buildings (Fachstelle für Hochschulbauten, FHB) for the University Council of the Swiss University Conference. This involves determining the Federal Government's building investment and building use contributions.

Governance

In 2019, a report on risks in real estate management was prepared for the first time by the office of the ETH Board. Together with the six institutions, the real estate portfolio was systematically checked for risks to the owner and specific measures were defined to mitigate the identified risks. The report was approved by the Audit Committee and duly noted by the ETH Board. This risk analysis provides proof of the careful management of the Federal Government's real estate that has been made available for use.

The audit mandate for the possible transfer of ownership of the real estate from the Federal Government to the ETH Domain, which began in the previous year, was stepped up by the ETH Board in 2019 with external support. The Federal Council has decided that the audit mandate should be completed by summer 2020.

In July 2019, the Federal Council passed several decrees that also have an impact on the ETH Domain and its real estate management. The "structural reforms" obliged all building and real estate bodies to trial extensive flexibilisation of standard workplaces using the shared space approach in future. A proposal to this effect is currently being drawn up. In addition, an efficient use of space is to be achieved with a control model to be developed. With the "climate package", the Federal Council has adopted objectives and measures that are geared towards further reducing CO_2 emissions (see the Environment and Energy section on the right).

Great progress was made in collaboration with the institutions in the project on minimum standards for the management of construction projects. The standardisation of control tools as well as approval and reporting systems is intended to enhance the quality of construction projects further and simplify cooperation between the parties involved. This is also a challenge posed by the increasing digitalisation of processes, e.g. through the BIM method.

Environment and energy

Focus on climate protection

The ETH Domain has underscored its commitment to implementing the 2050 Energy Strategy since 2014 through its active involvement in the "Confederation – Exemplary in Energy" (VBE) initiative of the Federal Government. By the end of 2018, the ETH Domain had achieved an increase in efficiency of 35.4% compared with 2006. The initiative's target for 2020 is 25%, and that had already been exceeded before the end of the period. The share of renewable energies in final energy consumption rose from 44% to 76% in the same period. Renewable energy sources already cover 86% of the electricity demand. There has been an increase in absolute final energy consumption of 7.7% in the same period due to the continuous growth of the ETH Domain. Together with the institutions, the Real Estate department of the ETH Board has already prepared and defined the objectives and measures for the successor programme, VBE 2020–2030.

In July 2019, the Federal Council adopted the climate package with a clear commitment to climate protection and the reduction of greenhouse gas emissions required to achieve this. This is based on the actions outlined in the VBE 2020–2030 proposal, but tightens the targets for the stakeholders in the federal administration. CO_2 emissions are to be halved from their 2006 levels by 2030. The remaining unavoidable emissions are to be offset. The Federal Government intends to have achieved "carbon-neutral status" by 2030 that way. The main thrust of the measures in the ETH Domain concern electricity and heat production, building services engineering and the energy-efficient refurbishment of buildings in the portfolio. In addition to the building-specific measures, the ETH Domain is also to define a pathway to reducing mobility-related CO_2 emissions from air traffic by mid-2020, as well as a plan for the construction of vehicles powered by renewable energies and with the necessary charging infrastructure. The work on these proposals began in the reporting year and takes account of ongoing or completed measures to the institutions' energy and environmental management.

ETH Zurich applies the SGNI and/or the Minergie ECO certification standard consistently for new buildings and complete refurbishments. As part of the further expansion of the anergy grid, it commissioned the largest energy centre "HI" in 2019. Eawag will be constructing its building in conformity with the Minergie ECO standard at least. WSL has replaced the oil heating system at the Davos site with a groundwater heat pump and now produces 100% renewable heat. The PSI extracts over 50% of the heat from waste heat from its own large-scale research facilities and obtains the remaining heat from the district heating network. In pursuit of the same objective, EPFL has begun construction work for the renewal of the heating and cooling centre with a lake water heat pump. The new data centre will make a major contribution to increasing EPFL's efficiency. Built above the energy centre, it will be cooled in future by the cold lake water and the waste heat produced by the servers will be returned to the energy centre for recovery. An energy master plan is also being implemented on the Empa-Eawag site in Dübendorf. The new heat pump went into operation in 2019, efficiently refining the heat stored in the medium-temperature network, or in the seasonal anergy grid, into high temperature.

The institutions have long since identified mobility in general and air traffic in particular as one of the largest causes of CO_2 emissions and operate a mobility management system to promote sustainable mobility. Flight routes are included by all institutions, and emissions from air travel are largely offset. Activities for sustainable mobility are coordinated by a dedicated mobility platform via ETH Zurich and EPFL. Important initiatives in this area include the air travel project and active support for public transport, bike sharing schemes and electric mobility. ETH Zurich's goal for 2019–2025 is to reduce CO_2 emissions from air travel by 11% per capita compared with the average value between 2016–2018. With the launch of the "Travel less without loss" project, EPFL is also aiming to reduce the CO_2 footprint by choosing the most sustainable means of transport or increasing the use of video conferencing, without compromising scientific excellence. Eawag is running an initiative to reduce the number of business flights under the name "Fly Aware". The PSI has implemented various measures in the field of mobility, such as the expansion of the Brugg-PSI direct bus line, the introduction of an e-bike leasing scheme and the expansion of the charging infrastructure to 40 charging points for visitors' and employees' electric vehicles. The proportion of electrically operated PSI service vehicles could be increased to more than 30%, which means that the target value of 20% for 2022 has already been exceeded.

The institutions are seeking to reduce their ecological footprint even further. Potential is offered, for example, by the catering on campus. A better environmental balance can also be achieved here through the implementation of selective measures such as the increase in vegetarian and vegan products, reducing food waste, promoting regional and seasonal products and raising awareness among customers.

Strategic objective

WORKING CONDITIONS, EQUAL OPPORTUNITIES AND YOUNG SCIENTIFIC TALENT

Leadership culture and equal opportunities were the most important issues in the ETH Domain's human resources policy in 2019. All the institutions have implemented further measures to increase the proportion of women in STEM subjects and to reconcile family life and work. Awareness of the issues of leadership, support, employment and respect was significantly increased in all institutions.

Focus in 2019:
Leadership skills and equal opportunities
A wide range of measures to reinforce a supportive and sustainable human resources policy were implemented throughout the ETH Domain. ETH Zurich's "Leadership Development" programme focuses on the quality of leadership, especially among professors. EPFL conducted management training courses to build the leadership skills of professorial and management staff. Furthermore, it implemented a two-year action plan in 2019 to digitalise HR processes. The focus of the PSI, Empa and Eawag was on strengthening management training and specialist careers, improving mentoring and career support for doctoral and postdocs, and strengthening the issues of diversity and inclusion, as well as promoting women's careers in STEM subjects. In order to increase the proportion of women in research and leadership positions, WSL adopted a "Gender Action Plan", which sets out measures for recruitment, career path measures, mentoring and reconciling family life and work. Eawag's internal training programme also offered 34 different events on the topics of leadership skills and equal opportunities. The newly created Career Center at the PSI supports young researchers in their career development through consulting services and intensive networking with regional companies in the field of advanced technology and research.

Further development of the salary system
The basic principles of the salary system were set out more precisely throughout the ETH Domain with revised requirement profiles and further progress was made with the partial revision of the PVO-ETH human resources ordinance. The two universities, ETH Zurich and EPFL, as well as the research institutions, PSI, WSL, Empa and Eawag, signed up to the Charter of Equal Pay in the Public Sector in 2019. EPFL subjected all IT professions to a systematic review to ensure consistency, fairness and competitiveness in salaries.

Executive promotion and management development
ETH Zurich is offering professors and line managers new training and coaching opportunities. It has also developed additional offers for scientific staff, as well as for technical and administrative personnel. It organised the "Leadership 4 new faculty" event series for new assistant professors and the comparable "Leadership 4 faculty" event series for existing professorial staff. It also offers "Lateral Leadership" programmes for managers without authority to issue instructions.

EPFL conducted a management training course developed in-house with "tenure-track for assistant professors", consisting of individual coaching and human resources management. Senior EPFL staff trained them in the areas of emotional intelligence, collective performance, conflict management, recruiting success, change management and leadership. The PSI has been conducting the ongoing development of the CAS train-

ing on "Leadership in Science" for managers and expert personnel as a joint venture with the University of Applied Sciences and Arts Northwestern Switzerland (FHNW) since 2017. For the specific purposes of the expert career path, it further developed the Expert Development Programme based on the industrial model to promote specialists. Managers at WSL, Empa and Eawag also receive CPD in the form of management training courses and individual coaching, and have the opportunity to take part in the CAS "Leadership in Science", which is run jointly with the PSI at FHNW.

Scientific careers

The role profiles and careers for scientific personnel on permanent contracts (senior scientists) at ETH Zurich and EPFL have been discussed and refined since 2017. This has significantly increased transparency of the requirements and development prospects, giving postdocs and research associates clarity about possible academic development at the universities. After four to five years of fixed-term employment at the latest, WSL, Empa and Eawag perform mandatory career reviews in which specific measures and opportunities for a more long-term career are discussed. In 2019, the PSI reviewed how the perception of development opportunities has changed and found that there has been a marked increase in employees' expectations regarding their own development opportunities and future prospects, as well as about management and cooperation.

Supporting young scientists

To promote international scientific exchange, WSL organised and supported nine international "Summer and Winter Schools" in Switzerland and abroad in 2019. It held the 30th "European Dendroecological Field Week". WSL is also one of the eleven international partner organisations in the "MicroArctic" Innovative Training Network (ITN), which is training the next generation of experts in Arctic microbiology and biogeochemistry. A new ITN "TubInTrain" was also launched at the PSI in 2019, which is establishing a multidisciplinary doctoral programme in the field of neurodegenerative diseases and neurotoxicity with partners from six European countries. Children are introduced to the world of research through the online platform WSL-junior.ch, the Kihz Summer Camp and the "Junior Research" scheme in collaboration with ETH Zurich. The PSI, Empa and Eawag also ran holiday camps for children of primary school age. Year in, year out, countless children at all institutions get inspired by science and research on National Future Day. To strengthen the aspect of "changing roles", the PSI launched a poster campaign on Future Day with images of women in STEM careers.

Career opportunities for all roles

Managers and personnel throughout the ETH Domain have access to a wide range of continuing professional development and advisory services to help them develop their careers in an era of "lifelong learning", to maintain their employability, or if they need retraining. ETH Zurich and EPFL offer individual coaching in the areas of leadership, career, collaboration and conflict management, as well as tailor-made team development services for line managers at all operational levels. External continuing professional development courses are supported both financially and in terms of time. Line managers are urged to support employees in their career development. Workshops are organised to improve discussions and for presenting their own objectives. The PSI is involved in the national "Transferable Skills Programme" to promote interdisciplinary skills for doctoral students and postdocs. Participation is compulsory for young scientists with tenure-track at Empa. To provide a basis for discussing development and career opportunities, Eawag prepared specific staff discussion sheets for each role in 2019.

Supervision of doctoral students and postdocs

The employment conditions and support for doctoral students and postdocs were reviewed and adjusted in detail throughout the ETH Domain. The doctoral regulations of ETH Zurich are currently being revised and include measures such as co-supervision, an admissions colloquium as well as binding and regular site and staff meetings, with aspects such as progress report, collaboration and development for discussion. ETH Zurich launched the project "Scientific Careers, Advancement and Development of Postdocs and Research Associates". Steps are also taken at EPFL to hone task and development profiles, to boost leadership and supervision activities and to advance academic and professional careers. The PSI continued to develop the "Professional Development Support" scheme for the supervision of doctoral students and postdocs, involving compulsory training for people with support duties. The online course in "Ethics in Research" has been compulsory for all postdocs at the PSI since mid-2019. WSL has prepared guidelines for doctoral students and their supervisors to promote quality considerations that generally apply to a successful doctorate. Within the scope of the PhD club, doctoral students benefit from tailor-made continuing training opportunities. In addition to annual personal development planning, Empa and Eawag offer doctoral students and postdocs specific courses for planning their professional careers. Empa has issued comprehensive internal regulations for the development and support of doctoral students, which further enhance the quality of the training. Eawag is continually revising its varied range of support for doctoral and postdoctoral students.

Domestic labour force potential

The applicable regulations on the obligation to register jobs have been implemented throughout the ETH Domain since 1 July 2018. The corresponding statutory criteria and recommendations are taken into consideration in the recruitment of new employees. Vacan-

cies in the administrative and technical fields are published on Swiss job sites and reported to the regional employment agencies (RAV).

Professional integration

The entire ETH Domain employs people with disabilities and provides positions for work and practical trials. ETH Zurich's "Obstacle-free" project is designed to ensure barrier-free access to study and work. The first two sub-projects focusing on building access and impairments of sight and hearing are currently being implemented. Support services to compensate for disabilities are being defined and rolled out. Advice and support for reintegration in the workplace have also contributed towards a high reintegration rate at the PSI. In the case of job-related incapacity to work, WSL examines internal relocations and enables work trials to be carried out as part of IV reintegration measures. Empa and Eawag accommodate employees who have been on sick leave with adjusted job profiles and evaluate their employment situation appropriate to their personal circumstances.

Implementation of equal opportunities

Projects such as "Smart Staffing – Hinder Bias" to review and further optimise open, transparent and performance-dependent recruitment processes, the mentoring programme for women with leadership ambitions, the embedding of a "diversity module" in management training, in which "unconscious bias" is also an issue, and the continuation of the "Fix the Leaky Pipeline" programme show that diversity and equal opportunities issues are very much present in the ETH Domain. ETH Zurich is providing the financial resources for ten additional professorships to attract top female researchers as professors. At least two female professors are represented on each appointment committee. In the long term, the aim is to achieve a 50% quota of women in the recruitment of female professors. To mark its 50th anniversary, EPFL created portraits of 50 female professors and five alumnae to showcase the involvement of women in technical sciences. Some of the female professors were featured in short films on the French-speaking Swiss Television channel, RTS. Panel discussions were held at ETH Zurich, EPFL and WSL on Women's Strike Day on 14 June 2019. Various current figures and statistics on the quota of women as a whole, in managerial positions and in science were compiled in a poster campaign on the day of the strike. They were available for all employees to see. WSL was involved in the St Gallen Diversity Benchmarking. The results of this analysis were to be factored into the newly launched Gender Action Plan in 2019. The PSI shortlists at least one female candidate for each managerial post. In addition, the aim is to achieve a 15–20% quota of women in committees which are relevant to strategy and career development, as well as to verify the implementation of this requirement. Empa and Eawag, which carried out the "Respect Campaign" in 2019, were also careful to ensure diversity and equal opportunities in all employment categories.

A healthy balance between family life and work

Childcare arrangements throughout the ETH Domain are very family-friendly. ETH Zurich has transformed the "flexible childcare" pilot project in the university centre into a permanent service. A pilot project for emergency care was launched in January 2020. An advisory programme focusing on balancing family, studies and career was to be launched on 1 January 2020 in cooperation with the UND department. EPFL supports

To mark its 50th anniversary, EPFL commissioned portraits of 50 female professors and five alumnae to showcase the involvement of women in technical sciences.
› EPFL

postdoctoral parents in the early stages of parenthood with the Robert Gnehm scholarships, allowing them to devote more time to their child and, at the same time, reduce their academic workload. PSI employees also benefit from the comprehensive flexible care offered by the KIHZ foundation (KIHZ Flex, KIHZ Mobil). In 2019, WSL continued the holiday week with "kihz", which enables parents from right across the ETH Domain to work during the school summer holidays and have their children looked after by a team of professional staff at WSL. Empa has won a number of awards for its family-friendly employment conditions: the "Family AND Career" award for "Best Practice", the "Prix BalanceZH" and the "HR Excellence in Research" from the European Commission Research & Innovation. Eawag also carried out an analysis of its family-friendly approach in cooperation with the UND department. It supports employees in managing a healthy balance between work and family life, achieving a glowing result in the staff survey conducted at the end of 2018.

Support for diversity

In 2019, ETH Zurich devised various initiatives to be implemented in 2020, such as workshops on promoting diversity, the integration of a module on diversity management in the planned leadership training programme and a mentoring project for foreign doctoral students from third countries. An awareness campaign was launched in autumn 2019 on the themes of "Diversity" and "Unconscious Bias". Activities to promote a culture of equality and integration at ETH Zurich and EPFL focused on exchange and dialogue. The executive boards were in attendance at the activities on both campuses on Women's Strike Day on 14 June and also gave employees the opportunity to participate. Issues of diversity were addressed during a round-table meeting to discuss strategic issues for the institution. Specific proposals were included for 2020. The PSI took second place in the 2018 Diversity Index run by Lucerne University of Applied Sciences and Arts. The results of this served to determine the current situation and to define further priorities and fields of action. The Diversity Award for management was presented at the 2019 New Year's Information event. A variety of measures were developed at WSL that are set to be implemented in 2020. Among other things, they developed proposals for workshops to promote diversity (reducing the "unconscious bias"), language courses and a mentoring project for foreign doctoral students, especially those from third countries. Empa and Eawag are also committed to ensuring gender balance at management level. Equal opportunities and diversity issues are constantly being developed and adapted to reflect needs.

Occupational safety, protection of privacy and health

All institutions offer comprehensive counselling services for supervisors and employees on long-term absences, reintegration and the protection of privacy. ETH Zurich created the position of an occupational health professional to ensure and provide training in health protection in laboratories and workshops. The aim is to improve occupational safety during pregnancy, health checks on commencing occupational training, as well as services in the event of psychosocial stress. Support for long-term absences and reintegration was further expanded. EPFL reviewed its structures and procedures with regard to all forms of "harassment". It set up the "Respect" unit and a support network with specific accounts. The PSI continued the measures initiated in the Safe@Work project such as the focused training of managers and the periodic implementation of awareness campaigns. Since 2019 there has been mandatory training for managers on health and safety, as well as prevention. Training courses and workshops such as WSL's "tree climbing" programme or the Health Day in summer 2019 are also being organised at Empa and Eawag.

Training of apprentices

In 2019, ETH Zurich provided 170 apprenticeship places in 15 occupational fields in teaching workshops and laboratories. The newly developed induction weeks contribute towards ensuring a good start in the world of work. EPFL trains more than 100 apprentices. A dedicated internship portal has been created for school leavers to recruit future apprentices. The PSI trains more than 100 apprentices in 15 occupations and has recently started offering apprenticeships for young people with disabilities or with less successful school-leaving qualifications. PSI students are regular recipients of regional and national awards, such as a silver medal (electronics technicians) and two diplomas, coming 5th in each case, (electronics technicians and computer scientists) at SwissSkills 2019. The best rating of "excellent" was achieved in the national "Schweizer Jugend forscht – Stay curious!" competition in 2019 (electronics technicians, year 4). WSL offered places for 15 apprentices in Birmensdorf and Davos in 2019. It supports lower-achievers with additional support programmes to help them successfully complete their apprenticeships. According to a study conducted by the "Great place to work" company, Empa is one of the best apprenticeship employers in Switzerland. It offers over 40 apprentices in ten different occupations a broad, thorough and varied vocational training. Eawag trained a total of 25 apprentices and is preventing youth unemployment by enabling apprentices to continue working for a fixed-term period after completing their apprenticeship.

Conclusion, outlook and objectives

Raising awareness of the issues of leadership and respect, support and employment enables challenges in leadership and cooperation to be addressed constructively at an early stage. With a view towards improving advice and mediation in critical leadership and cooperation situations, all institutions have implemented further initiatives such as advice centres and campaigns. In addition, a mediation commission will be introduced for the ETH Domain in 2020 in accordance

with the Equal Opportunities Act. Diversity and equal opportunities issues will become even more important in 2019. The ETH Domain will maintain its commitment to respectful interaction and gender issues (LGBTQIA+). Attention must also be paid to the political climate between Switzerland and the EU and its impact on bilateral agreements, so that changes in the relevant legislation can be factored into planning and be taken into account in plenty of time.

Key Figures Personnel

On 31 December 2019, the headcount in the ETH Domain stood at 22,599 employment contracts (ECs), or 19,440.2 full-time equivalents (FTEs) (see Fig. 18, p. 94). With an increase of 250 ECs (+1.1%) or 319.8 FTEs, the reported growth in headcount settled at the previous years' level. As had been anticipated, the increase in headcount in 2019 was lower than in the previous year because it had been significantly above the usual values of between 2% and 3% in 2018 due to the additional 515 ECs created at ETH Zurich for system-related reasons. The scientific personnel, which also includes doctoral students, remains the largest function group in the ETH Domain with 13,617 ECs (11,608.0 FTEs) (60.3% of the total headcount, see Fig. 18, p. 94), followed by the technical staff, which accounts for 3,954 ECs (3,591.8 FTEs) or 17.5% of the headcount. 16.4% of all employees or 3,708 ECs (2,952.3 FTEs) are administrative employees and 2.0% are apprentices. Professors account for 862 ECs (830.5 FTEs) or 3.8% of the total headcount.

Professors
In 2019, ETH Zurich and EPFL had a total of 691 full and associate professors and 122 assistant professors with tenure track (TT) and 49 assistant professors without TT (see Fig. 19, p. 94). The proportion of women in the three categories grew from 15.5% to 17.2% in 2019. The figures were 14.8% for full and associate professors, 26.2% for assistant professors with TT and 28.6% for assistant professors without TT. In 2019, 66.6% of the total of 862 professors came from abroad (2018: 67.1%). Of these 52.4% (2018: 52.1%) came from the EU area, and 14.2% from other countries (2018: 15.0%) (see Fig. 20, p. 95).

Financing the professorships
Of the 524 professors (506.9 FTEs) employed at ETH Zurich as of 31 December 2019, 460.8 FTEs (90.9%) were financed by the total federal contribution, 19.4 FTEs (3.8%) by SNSF, 4.9 FTEs (1.0%) by EU research programmes, and 21.6 FTEs (4.3%) by third-party financial research contributions, as well as by donations and bequests.

Of the 338 professors (323.6 FTEs) employed at EPFL as of 31 December 2019, 307.0 FTEs (94.9%) were financed by the total federal contribution, 5.6 FTEs by the SNSF and 0.1 FTEs by Innosuisse (total 1.7%), no posts by EU research programmes, and 10.9 FTEs (3.4%) by third-party financial research contributions, as well as by donations and bequests.

Proportion of women
At the end of 2019, the proportion of women in the ETH Domain stood at 35.1%. This figure rose in all institutions. The proportions vary according to discipline and institution. The lowest proportions of women are at the PSI and Empa; the highest are at Eawag (see Fig. 23, p. 96).

Apprentices
The ETH Domain offered 458 apprentices an apprenticeship in more than 20 different career paths. Women accounted for 32.1% of apprentices in 2019.

KEY FIGURES

Monitoring table on the strategic objectives set by the Federal Council

Fig. 5: Monitoring table on the strategic objectives set by the Federal Council for the ETH Domain for 2017–2020

	Reference values			Monitoring		
Indicators	2008	2013	2016	2017	2018	2019
TEACHING						
Students and doctoral students of ETH Zurich and EPFL (headcount)						
New admissions						
At Bachelor's level	4,052	5,255	5,531	4,756	4,827	4,966
Students	**16,233**	**22,099**	**24,217**	**25,059**	**26,140**	**27,275**
Proportion of women (%)	29.3	29.1	29.7	30.6	31.2	31.5
Proportion of foreign nationals (%)	27.3	35.5	37.4	38.4	39.3	40.7
At Bachelor's level	10,138	13,995	14,727	14,385	14,792	15,243
Proportion of women (%)	28.8	28.6	30.0	30.6	31.6	31.9
Proportion of foreign nationals (%)	23.8	30.9	31.6	29.4	30.4	31.9
At Master's level	4,649	7,241	8,662	8,895	9,517	10,163
Proportion of women (%)	28.0	29.4	28.5	29.4	29.6	29.8
Proportion of foreign nationals (%)	34.4	43.1	46.1	45.4	46.3	47.6
At Diploma level	751	0	0	0	0	0
On MAS / MBA programmes	695	863	828	840	827	809
Proportion of women (%)	34.2	34.6	37.9	38.8	40.6	40.3
Proportion of foreign nationals (%)	48.1	45.7	50.2	51.5	50.1	46.7
Mobility students [1]	–	–	–	939	1,004	1,060
Proportion of women (%)	–	–	–	35.5	32.9	34.9
Proportion of foreign nationals (%)	–	–	–	96.5	96.6	96.0
Supervision ratio						
Bachelor's and Master's students per professor	25.1	27.7	29.2	28.3	29.7	30.6
Doctoral students	**4,823**	**5,947**	**6,134**	**6,234**	**6,391**	**6,367**
Proportion of women (%)	28.6	30.4	31.0	30.8	31.4	32.8
Proportion of foreign nationals (%)	62.7	72.6	74.3	75.0	76.3	76.9
Supervision ratio						
Doctoral students per professor	7.8	7.7	7.7	7.6	7.8	7.7
Students and doctoral students	**21,056**	**28,046**	**30,351**	**31,293**	**32,531**	**33,642**
Proportion of women (%)	29.1	29.4	30.0	30.6	31.3	31.7
Proportion of foreign nationals (%)	35.4	43.3	44.9	45.7	46.6	47.5
Supervision ratio						
Students and doctoral students per professor	34.0	36.5	37.9	38.0	39.8	40.5
Degrees						
Bachelor	1,656	2,249	2,500	2,602	2,686	2,876
Diploma, Master	1,978	2,663	2,989	3,065	3,240	3,368
MAS / MBA	336	346	303	394	343	324
Doctorate	832	993	1,256	1,258	1,209	1,290
Teaching and supervision by the research institutes						
Teaching hours	15,569	15,670	18,023	17,992	18,659	18,717
Bachelor's, Master's and Diploma projects	391	532	575	602	623	639
Doctoral students	700	797	783	807	854	837
Proportion of women (%)	36.1	36.3	39.8	39.0	38.4	38.2
Proportion enrolled in the ETH Domain (%)	66.1	67.9	67.4	67.7	68.6	67.9
Proportion enrolled at a foreign university (%)	17.3	13.4	11.7	10.3	8.8	9.8

	Reference values			Monitoring		
Indicators	2008	2013	2016	2017	2018	2019
RESEARCH						
Publications[2]	–	–	–	–	–	–
Research contributions, mandates and scientific services (in CHF millions)	–	–	**772.7**	**743.2**	**755.2**	**779.1**
of which Swiss National Science Foundation (SNSF)	141.6	209.0	257.4	260.3	254.7	259.7
of which Innosuisse	26.1	36.8	50.6	62.6	55.5	49.3
of which EU Framework programmes for Research and Innovation (FP)	97.7	135.2	142.1	139.2	141.8	151.6
KNOWLEDGE AND TECHNOLOGY TRANSFER (KTT)						
Invention disclosures[3]	–	–	–	343	358	329
Software notifications[3]	–	–	–	26	36	40
Patents	125	193	230	206	230	224
Licences	178	223	353	377	341	324
Spin-offs	46	43	50	48	55	59
STAFF (FTE)						
Professors	619.4	767.7	800.8	823.8	818.3	830.5
Proportion of women (%)	10.7	12.4	13.9	14.8	15.4	17.2
Proportion of foreign nationals (%)	61.8	67.1	68.0	67.2	67.3	66.8
Scientific staff	7,956.5	9,927.3	11,053.9	11,204.4	11,542.3	11,608.0
Technical staff	2,957.6	3,157.3	3,355.1	3,439.8	3,494.0	3,591.8
Administrative staff	1,771.2	2,279.0	2,577.8	2,690.0	2,804.7	2,952.3
Apprentices	386.0	435.0	463.7	473.6	461.1	457.6
FINANCES / REAL ESTATE						
Total federal contribution (expenditure ceiling perspective) (in CHF million)	**1,949.4**	**2,271.4**	**2,453.8**	**2,530.8**	**2,530.9**	**2,581.2**
of which federal financial contribution	1,778.4	2,073.9	2,288.7	2,377.9	2,356.7	2,372.6
of which investment credit for construction in the ETH Domain[4]	170.9	197.5	165.1	152.9	174.2	208.6

[1] Mobility students have constituted a separate student category since 2017.
[2] Publishing activity is assessed every four years as part of the intermediate evaluation.
[3] Additional KTT indicators introduced in 2017.
[4] The values for 2018 and 2019 deviate from the State financial statement (see side note p. 102).

Indicators and counting methods for the monitoring table and the academic achievement report

If not specified in more detail, the term "students" is always understood to mean students at Bachelor's and Master's levels, students on Master of Advanced Studies and Master of Business Administration (MAS/MBA) continuing education programmes, and mobility students (students who are studying at one of the Federal Institutes of Technology for one or two semesters but are registered at another university). Doctoral students are defined as a separate category. In cases of simultaneous enrolment on several disciplines or academic levels, the prioritised discipline or level is counted.

Students and doctoral students are included in "headcount". Foreign students and doctoral students form two sub-categories: foreign-educated foreign nationals who were resident abroad while obtaining the relevant necessary qualifications, and Swiss-educated foreign nationals who were resident in Switzerland while obtaining the relevant necessary qualifications. The employment level of all staff is counted in terms of full-time equivalents (FTE). Professors – both full and associate, as well as assistant professors, including those recipients of the Swiss National Science Foundation (SNSF) Eccellenza professorial fellowship – who are employed at one of the two Federal Institutes of Technology are taken into account in calculating the supervision ratio. Senior scientists and *Maîtres d'enseignement et de recherche* (MER) from both Federal Institutes of Technology correspond to the academic staff in management roles or senior management staff. Some of them are adjunct professors. To determine the "expanded" supervision ratio, the Senior Scientists and MER of both Federal Institutes of Technology are added to the professors. The teaching hours delivered by the research institutes do not include preparation time, only the time spent in the presence of students.

Academic achievement report

Fig. 6: Students and doctoral students by discipline

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Δ 2018 / 2019	
												in %
Architecture	**2,994**	**3,098**	**3,177**	**3,097**	**3,066**	**3,060**	**3,030**	**3,047**	**3,041**	**3,090**	**49**	**1.6**
ETH Zurich	1,848	1,900	1,950	1,852	1,783	1,805	1,771	1,823	1,855	1,904	49	2.6
EPFL	1,146	1,198	1,227	1,245	1,283	1,255	1,259	1,224	1,186	1,186	0	0.0
Civil and Geomatic Engineering	**2,405**	**2,727**	**2,900**	**3,074**	**2,946**	**2,882**	**2,860**	**2,791**	**2,777**	**2,716**	**–61**	**–2.2**
ETH Zurich	1,434	1,576	1,629	1,740	1,731	1,716	1,701	1,688	1,667	1,614	–53	–3.2
EPFL	971	1,151	1,271	1,334	1,215	1,166	1,159	1,103	1,110	1,102	–8	–0.7
Engineering Sciences	**5,985**	**6,391**	**6,816**	**7,245**	**7,502**	**7,903**	**8,069**	**8,398**	**8,699**	**9,081**	**382**	**4.4**
ETH Zurich	3,901	4,167	4,341	4,549	4,729	4,930	4,993	5,135	5,224	5,467	243	4.7
EPFL	2,084	2,224	2,475	2,696	2,773	2,973	3,076	3,263	3,475	3,614	139	4.0
Information and Communications Technology	**2,070**	**2,253**	**2,367**	**2,536**	**2,665**	**2,809**	**3,033**	**3,261**	**3,648**	**4,031**	**383**	**10.5**
ETH Zurich	1,029	1,082	1,083	1,158	1,247	1,405	1,536	1,753	1,991	2,246	255	12.8
EPFL	1,041	1,171	1,284	1,378	1,418	1,404	1,497	1,508	1,657	1,785	128	7.7
Exact and Natural Sciences	**4,155**	**4,476**	**4,780**	**4,883**	**4,944**	**5,145**	**5,442**	**5,595**	**5,810**	**5,940**	**130**	**2.2**
ETH Zurich	2,606	2,790	2,903	2,972	3,024	3,157	3,352	3,505	3,691	3,794	103	2.8
EPFL	1,549	1,686	1,877	1,911	1,920	1,988	2,090	2,090	2,119	2,146	27	1.3
Human Medicine[1]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**99**	**192**	**286**	**94**	**49.0**
ETH Zurich	–	–	–	–	–	–	–	99	192	286	94	49.0
Life Sciences	**3,176**	**3,314**	**3,708**	**3,879**	**3,990**	**4,051**	**4,216**	**4,312**	**4,500**	**4,624**	**124**	**2.8**
ETH Zurich	2,472	2,551	2,823	2,923	3,012	3,044	3,162	3,218	3,326	3,433	107	3.2
EPFL	704	763	885	956	978	1,007	1,054	1,094	1,174	1,191	17	1.4
System-oriented Natural Sciences	**2,205**	**2,261**	**2,201**	**2,159**	**2,211**	**2,284**	**2,411**	**2,437**	**2,520**	**2,538**	**18**	**0.7**
ETH Zurich	2,205	2,261	2,201	2,159	2,211	2,284	2,411	2,437	2,520	2,538	18	0.7
Management, Technology, Economics	**859**	**833**	**870**	**897**	**913**	**913**	**972**	**973**	**966**	**954**	**–12**	**–1.2**
ETH Zurich	592	584	583	549	579	582	571	583	573	560	–13	–2.3
EPFL	267	249	287	348	334	331	401	390	393	394	1	0.3
Humanities, Social and Political Sciences[2]	**255**	**276**	**268**	**276**	**300**	**310**	**318**	**380**	**378**	**382**	**4**	**1.1**
ETH Zurich	255	276	268	276	300	310	318	366	358	351	–7	–2.0
EPFL	–	–	–	–	–	–	–	14	20	31	11	55.0
Total students and doctoral students	**24,104**	**25,629**	**27,087**	**28,046**	**28,537**	**29,357**	**30,351**	**31,293**	**32,531**	**33,642**	**1,111**	**3.4**
ETH Zurich	16,342	17,187	17,781	18,178	18,616	19,233	19,815	20,607	21,397	22,193	796	3.7
EPFL	7,762	8,442	9,306	9,868	9,921	10,124	10,536	10,686	11,134	11,449	315	2.8
Women	**7,149**	**7,585**	**7,973**	**8,238**	**8,414**	**8,677**	**9,091**	**9,587**	**10,167**	**10,675**	**508**	**5.0**
ETH Zurich	5,050	5,292	5,445	5,560	5,701	5,873	6,164	6,563	6,917	7,304	387	5.6
EPFL	2,099	2,293	2,528	2,678	2,713	2,804	2,927	3,024	3,250	3,371	121	3.7
Foreign nationals	**9,488**	**10,456**	**11,437**	**12,152**	**12,354**	**12,804**	**13,615**	**14,290**	**15,160**	**15,993**	**833**	**5.5**
ETH Zurich	5,698	6,205	6,559	6,751	6,949	7,226	7,563	7,972	8,433	8,876	443	5.3
EPFL	3,790	4,251	4,878	5,401	5,405	5,578	6,052	6,318	6,727	7,117	390	5.8

[1] ETH Zurich introduced a Bachelor's degree in Human Medicine in 2017.
[2] EPFL introduced a Master's degree in Digital Humanities in 2017.

Fig. 7: Students and doctoral students by academic level

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Δ 2018 / 2019	
												in %
Bachelor's programmes	**11,716**	**12,600**	**13,359**	**13,995**	**13,944**	**14,292**	**14,727**	**14,385**	**14,792**	**15,243**	**451**	**3.0**
ETH Zurich	7,757	8,236	8,468	8,817	8,820	9,087	9,309	9,262	9,517	9,895	378	4.0
EPFL	3,959	4,364	4,891	5,178	5,124	5,205	5,418	5,123	5,275	5,348	73	1.4
Master's programmes	**5,997**	**6,568**	**6,981**	**7,241**	**7,781**	**8,126**	**8,662**	**8,895**	**9,517**	**10,163**	**646**	**6.8**
ETH Zurich	4,281	4,607	4,755	4,811	5,187	5,480	5,861	6,158	6,590	7,037	447	6.8
EPFL	1,716	1,961	2,226	2,430	2,594	2,646	2,801	2,737	2,927	3,126	199	6.8
Diploma programmes	**191**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**–**	**–**
ETH Zurich	191	0	0	0	0	0	0	0	0	0	–	–
EPFL	0	0	0	0	0	0	0	0	0	0	–	–
MAS / MBA	**792**	**801**	**911**	**863**	**805**	**836**	**828**	**840**	**827**	**809**	**–18**	**–2.2**
ETH Zurich	606	659	763	661	634	640	635	646	635	626	–9	–1.4
EPFL	186	142	148	202	171	196	193	194	192	183	–9	–4.7
Mobility[1]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**939**	**1,004**	**1,060**	**56**	**5.6**
ETH Zurich	–	–	–	–	–	–	–	449	480	467	–13	–2.7
EPFL	–	–	–	–	–	–	–	490	524	593	69	13.2
Total number of students	**18,696**	**19,969**	**21,251**	**22,099**	**22,530**	**23,254**	**24,217**	**25,059**	**26,140**	**27,275**	**1,135**	**4.3**
ETH Zurich	12,835	13,502	13,986	14,289	14,641	15,207	15,805	16,515	17,222	18,025	803	4.7
EPFL	5,861	6,467	7,265	7,810	7,889	8,047	8,412	8,544	8,918	9,250	332	3.7
Doctoral programmes	**5,408**	**5,660**	**5,836**	**5,947**	**6,007**	**6,103**	**6,134**	**6,234**	**6,391**	**6,367**	**–24**	**–0.4**
ETH Zurich	3,507	3,685	3,795	3,889	3,975	4,026	4,010	4,092	4,175	4,168	–7	–0.2
EPFL	1,901	1,975	2,041	2,058	2,032	2,077	2,124	2,142	2,216	2,199	–17	–0.8
Total students and doctoral students	**24,104**	**25,629**	**27,087**	**28,046**	**28,537**	**29,357**	**30,351**	**31,293**	**32,531**	**33,642**	**1,111**	**3.4**
ETH Zurich	16,342	17,187	17,781	18,178	18,616	19,233	19,815	20,607	21,397	22,193	796	3.7
EPFL	7,762	8,442	9,306	9,868	9,921	10,124	10,536	10,686	11,134	11,449	315	2.8

[1] Mobility students have constituted a separate student category since 2017.

Different counting methods used by the ETH Board and the FSO

The method of counting students and doctoral candidates used by the ETH Board differs from that used by the Federal Statistical Office (FSO). The differences are mainly due to the different approaches and tasks of the organisations involved. The aim of the FSO's counting method, according to the Swiss University Information System, is to achieve comparability nationwide; the ETH Board, on the other hand, is concerned with reflecting the Federal Council's strategic objectives, the priorities and the special aspects of the ETH Domain as effectively as possible. The difference in the figures is largely due to the fact that the ETH Board includes incoming mobility students in the total number of students.

Mobility students have constituted a separate student category since 2017. Prior to then, mobility students were included in the figures for students at Bachelor's and Master's levels. This should be borne in mind when comparing with previous years. Where exchange students are counted is important for the ETH Domain for reporting on the strategic objectives – especially for the sub-objective of "Promotion of national and international exchanges".

Fig. 8: New admissions to the Bachelor's level at ETH Zurich and EPFL

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Δ 2018 / 2019	
												in %
Architecture	671	646	599	604	564	573	569	437	450	468	18	4.0
Civil and Geomatic Engineering	556	638	620	613	486	493	488	366	370	383	13	3.5
Engineering Sciences	1,183	1,240	1,354	1,429	1,393	1,550	1,518	1,350	1,303	1,353	50	3.8
Information and Communications Technology	425	448	465	547	595	596	679	582	662	708	46	6.9
Exact and Natural Sciences	832	954	986	969	952	1,001	1,108	985	928	952	24	2.6
Human Medicine[1]	–	–	–	–	–	–	–	100	100	100	0	0.0
Life Sciences	529	578	700	744	721	695	778	635	696	725	29	4.2
System-oriented Natural Sciences	318	321	336	335	316	366	372	288	307	259	–48	–15.6
Management, Technology, Economics	–	–	–	–	–	–	–	–	–	–	–	–
Humanities, Social and Political Sciences	13	13	12	14	14	16	19	13	11	18	7	63.6
Total	**4,527**	**4,838**	**5,072**	**5,255**	**5,041**	**5,290**	**5,531**	**4,756**	**4,827**	**4,966**	**139**	**2.9**

[1] ETH Zurich introduced a Bachelor's degree in Human Medicine in 2017. New admissions in this discipline are limited to 100 and will therefore remain stable over the years.

Fig. 9: Percentage of women among students and doctoral students at ETH Zurich and EPFL

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
% at the Bachelor's level	28.9	29.4	29.2	28.6	28.7	29.2	30.0	30.6	31.6	31.9
% at the Master's level	29.2	29.2	28.7	29.4	29.5	28.6	28.5	29.4	29.6	29.8
% on MAS / MBA programmes	37.0	37.1	36.7	34.6	35.0	38.6	37.9	38.8	40.6	40.3
% of mobility students	–	–	–	–	–	–	–	35.5	32.9	34.9
% at the doctoral level	30.4	29.4	29.8	30.4	30.6	30.6	31.0	30.8	31.4	32.8

Fig. 10: Percentage of foreign nationals among students and doctoral students at ETH Zurich and EPFL

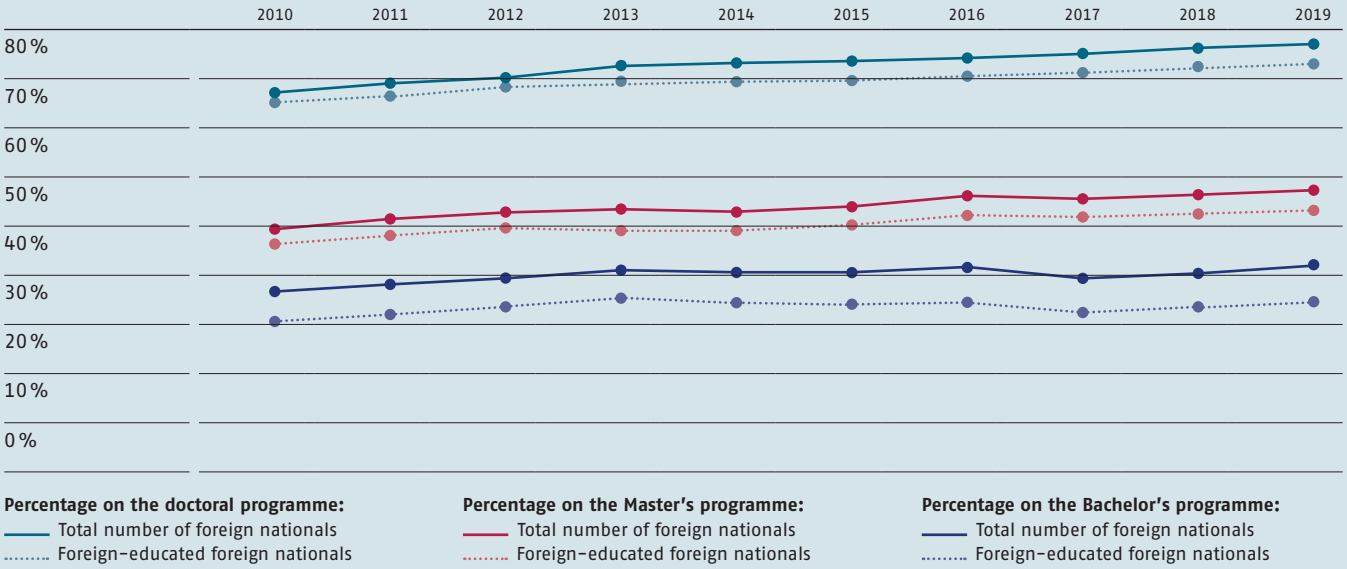


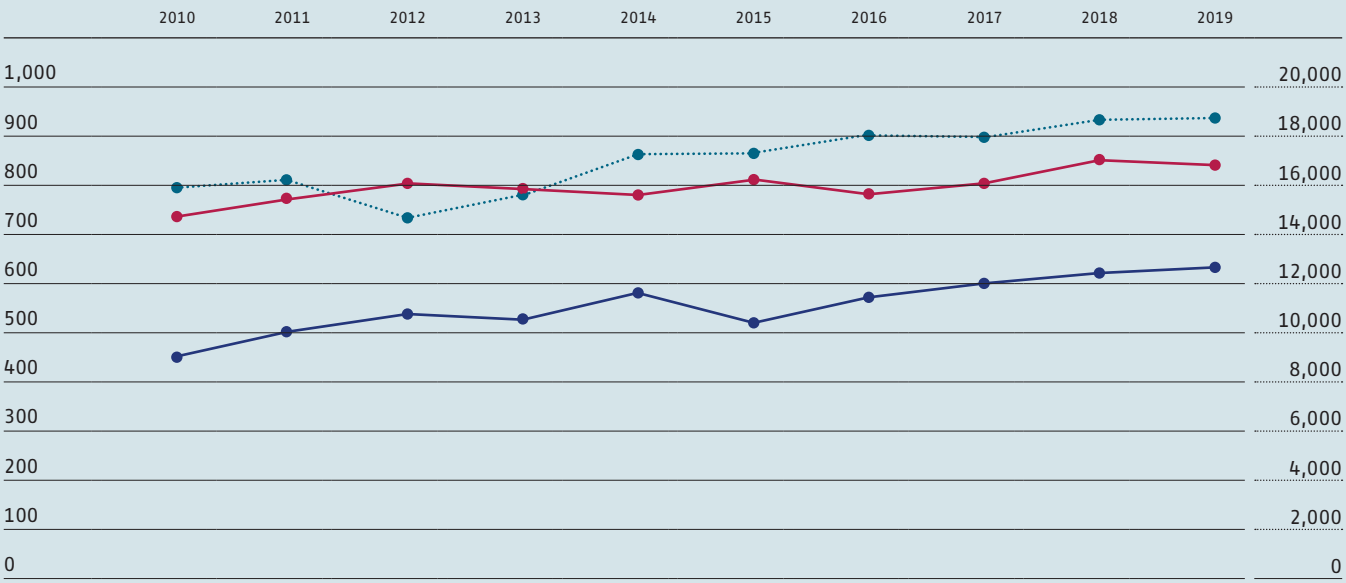
Fig. 11: Supervision ratios at ETH Zurich and EPFL

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Supervision ratio	**35.1**	**35.8**	**36.4**	**36.5**	**36.8**	**37.4**	**37.9**	**38.0**	**39.8**	**40.5**
at Bachelor's / Master's level	26.1	26.8	27.3	27.7	28.0	28.6	29.2	28.3	29.7	30.6
at Doctoral level	7.9	7.9	7.8	7.7	7.8	7.8	7.7	7.6	7.8	7.7
Extended supervision ratio	**22.9**	**23.7**	**24.5**	**24.7**	**24.7**	**25.3**	**25.7**	**25.8**	**26.8**	**27.4**
at Bachelor's / Master's level	17.0	17.8	18.4	18.7	18.8	19.3	19.8	19.2	20.0	20.7
at Doctoral level	5.1	5.2	5.3	5.2	5.2	5.3	5.2	5.1	5.3	5.2

Fig. 12: Degrees awarded by academic level

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Δ 2018 / 2019	
												in %
Bachelor	**1,900**	**1,988**	**2,216**	**2,249**	**2,538**	**2,528**	**2,500**	**2,602**	**2,686**	**2,876**	**190**	**7.1**
ETH Zurich	1,283	1,304	1,447	1,447	1,579	1,564	1,571	1,606	1,678	1,758	80	4.8
EPFL	617	684	769	802	959	964	929	996	1,008	1,118	110	10.9
Master / diploma	**1,898**	**2,159**	**2,320**	**2,663**	**2,711**	**2,821**	**2,989**	**3,065**	**3,240**	**3,368**	**128**	**4.0**
ETH Zurich	1,270	1,506	1,650	1,847	1,839	1,879	2,015	2,072	2,196	2,335	139	6.3
EPFL	628	653	670	816	872	942	974	993	1,044	1,033	–11	–1.1
MAS / MBA	**283**	**301**	**256**	**346**	**260**	**254**	**303**	**394**	**343**	**324**	**–19**	**–5.5**
ETH Zurich	174	203	184	228	205	175	203	272	232	245	13	5.6
EPFL	109	98	72	118	55	79	100	122	111	79	–32	–28.8
Doctorate	**986**	**1,027**	**1,095**	**993**	**1,197**	**1,109**	**1,256**	**1,258**	**1,209**	**1,290**	**81**	**6.7**
ETH Zurich	650	696	747	579	769	718	851	827	802	866	64	8.0
EPFL	336	331	348	414	428	391	405	431	407	424	17	4.2

Fig. 13: Teaching and supervision by research institutes



Left axis: Number of supervised Bachelor's, Master's, Diploma and doctoral theses
Right axis: Number of teaching hours per year

Number of supervised doctoral theses
Number of supervised Bachelor's, Master's and Diploma theses
Number of teaching hours per year

Knowledge and technology transfer

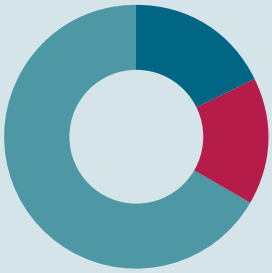
Fig. 14: Knowledge and technology transfer in the ETH Domain

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Invention disclosures[1]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**343**	**358**	**329**
ETH Zurich	–	–	–	–	–	–	–	171	205	159
EPFL	–	–	–	–	–	–	–	134	119	132
Research institutes	–	–	–	–	–	–	–	38	34	38
Software notifications[1, 2]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**26**	**36**	**40**
ETH Zurich	–	–	–	–	–	–	–	20	19	26
EPFL	–	–	–	–	–	–	–	6	13	13
Research institutes	–	–	–	–	–	–	–	0	4	1
Patents	**128**	**147**	**195**	**193**	**211**	**219**	**230**	**206**	**230**	**224**
ETH Zurich	63	72	87	103	82	98	109	84	109	102
EPFL	47	52	75	66	99	88	100	95	95	98
Research institutes	18	23	33	24	30	33	21	27	26	24
Licences	**178**	**194**	**230**	**223**	**270**	**311**	**353**	**377**	**341**	**324**
ETH Zurich	39	45	35	38	35	50	78	82	87	62
EPFL	45	50	31	41	46	48	58	50	39	50
Research institutes	94	99	164	144	189	213	217	245	215	212
Spin-offs	**38**	**40**	**38**	**43**	**49**	**48**	**50**	**48**	**55**	**59**
ETH Zurich	20	22	22	24	22	25	25	25	27	30
EPFL	14	15	12	12	24	18	20	15	25	23
Research institutes	4	3	4	7	3	5	5	8	3	6

[1] Invention disclosures and software notifications were introduced in 2017 as additional KTT indicators.
[2] Open Source Software not included

Licences

324



ETH Zurich	62
EPFL	50
Research institutes	212

Invention disclosures

329

Software notifications

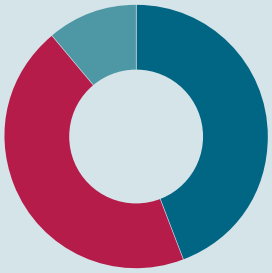
40

Spin-offs

59

Patents

224



ETH Zurich	102
EPFL	98
Research institutes	24

Fig. 15: Cooperation with the private and public sector

	2019	2018	2017
Collaboration contracts with the private sector	**570**	**594**	**507**
Financed by the private sector	**404**	**415**	**316**
ETH Zurich	163	149	122
EPFL	125	120	99
Research institutions	116	146	95
Financed by Innosuisse / FP *	**166**	**179**	**191**
ETH Zurich	55	74	57
EPFL	61	49	66
Research institutions	50	56	68
Collaboration contracts with the Swiss public sector	**278**	**261**	**285**
ETH Zurich	88	100	88
EPFL	51	43	54
Research institutions	139	118	143

Number of new cooperation agreements (research agreements and scientific services) with the private and Swiss public sector involving a volume of at least CHF 50,000 per contract. These indicators were introduced in 2018.
* FP: EU Framework Programmes for Research and Innovation

KTT indicators and counting methods

The patents correspond only to first filing, and the licences also include technology transfer agreements. The invention disclosures and software notifications correspond to the reports and notifications submitted in writing to the Technology Transfer Offices of the institutions of the ETH Domain in the reporting year. They reflect activities in the early phases of the innovation process, thereby supplementing the other KTT indicators. Open source software is not considered.

In order to reflect the cooperation between the institutions and private enterprise and the public sector, only recently concluded cooperation agreements are included. These are only research contracts and scientific services with a volume of at least CHF 50,000 per contract. Cooperation with the private sector is divided into two categories: projects that are directly financed by industry in Switzerland or abroad; and those funded by Innosuisse or the EU Research Framework Programme for Research and Innovation (FP). Cooperation with the public sector includes contracts with public sector institutions in Switzerland, but not those with national or international research funding organisations and foundations.

Rankings observed worldwide

The universities are assessed and ranked by institutions and businesses using various methods. THE (Times Higher Education World University Rankings) uses 13 key performance indicators for teaching (30% weighting), research (30%), citations (30%), international outlook (7.5%) and funding by industry (2.5%). QS (QS World University Rankings) focuses mainly on reputation (with a 40% weighting on academic reputation and 10% on reputation of graduates among employers), followed by the supervision ratio (20%), citations (20%) and international outlook (10%). ARWU (Academic Ranking of World Universities of Shanghai Ranking Consultancy) makes use of performance indicators for the quality of graduates and teaching staff that are based on the number of prestigious awards received (Nobel Prize, Fields Medal) and the number of frequently-cited researchers.

The publication activity is judged on the basis of the number of publications that have appeared in a select group of the most respected journals, and the ratio between the number of publications and the number of researchers at an institution. CWTS Leiden (Centre for Science and Technology Studies Leiden Ranking) is based solely on the publication activity of the universities, using this to calculate the indicators to assess research performance. One commonly used indicator for ranking the universities in the CWTS Leiden ranking is the proportion of publications each university has among the top 10% of the most-cited publications in the relevant discipline (PP(top 10%)). The rankings shown for both Federal Institutes of Technology shown (see Fig. 16) are based on this indicator.

University rankings

Fig. 16: Rankings of ETH Zurich (blue) and EPFL (red) according to the THE, QS, ARWU and CWTS Leiden Rankings in 2019/2020

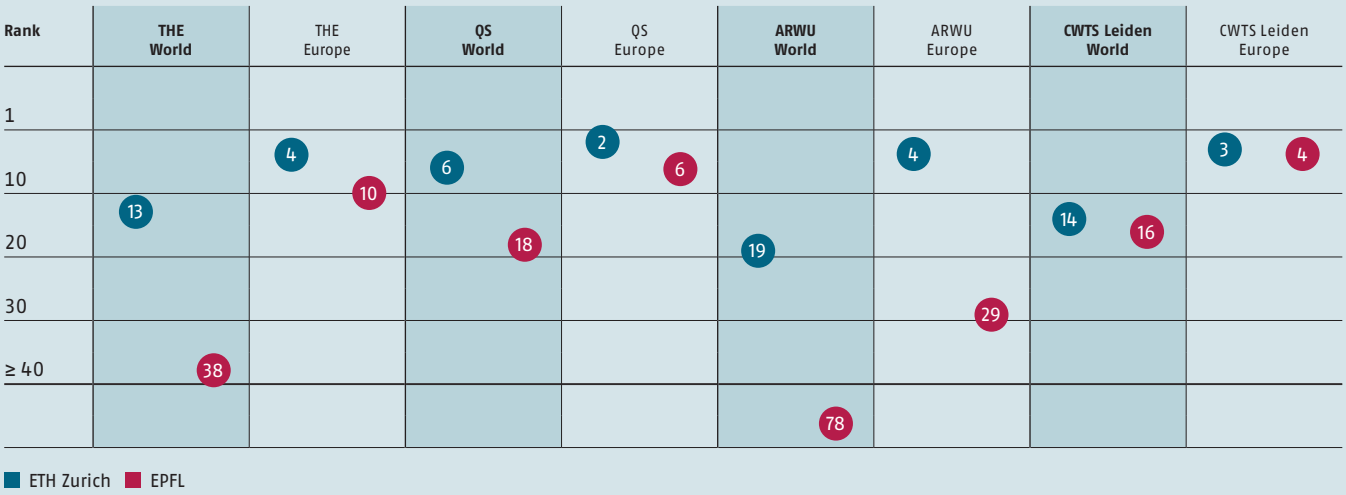
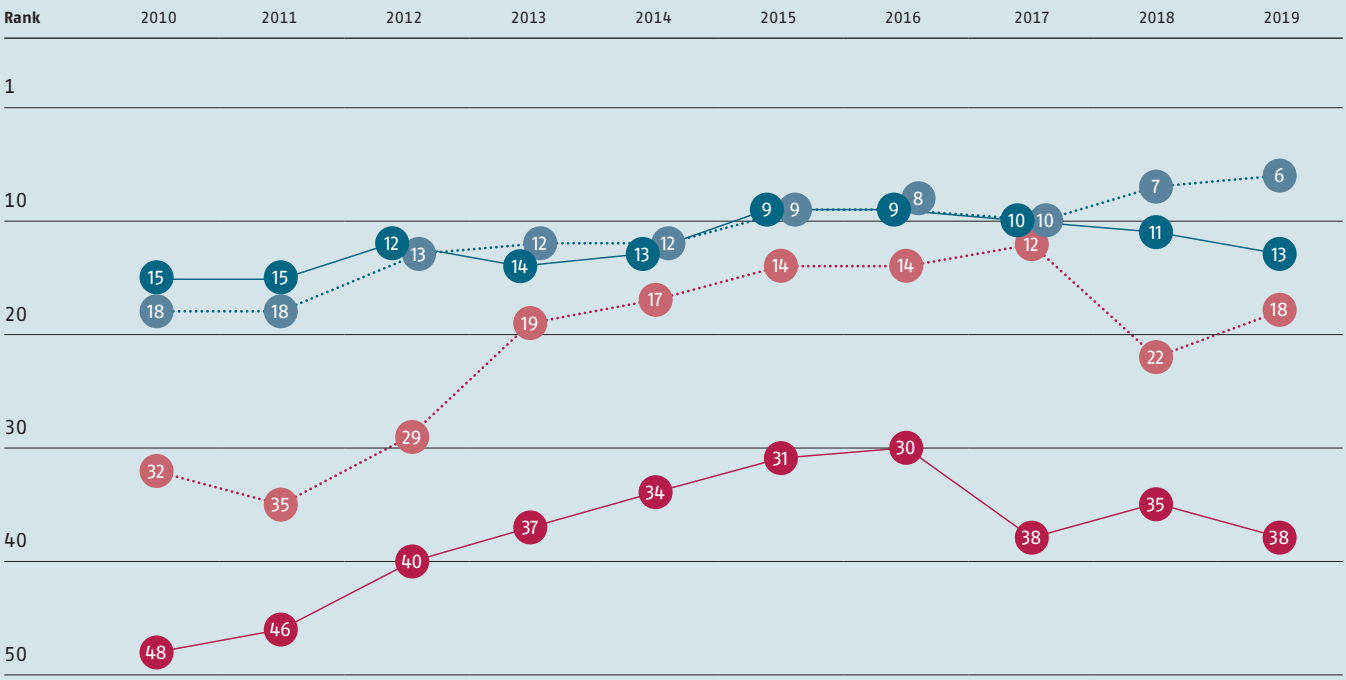


Fig. 17: Rankings of ETH Zurich (blue) and EPFL (red) according to the THE and QS World Rankings 2010–2019



THE **Times Higher Education World University Rankings** from TES Global Limited, London
QS **QS World University Rankings** from Quacquarelli Symonds Limited, London
ARWU **Academic Ranking of World Universities** from ShanghaiRanking Consultancy
CWTS Leiden **CWTS Leiden Ranking** from the Centre for Science and Technology Studies (CWTS) of the University of Leiden, Netherlands; Indicator used PP (top 10%) (see box on the left)

Personnel

Fig. 18: Headcount and employment level by function group

	Men			Women			ETH Domain		
2019	EC	FTE	ø EL %	EC	FTE	ø EL %	EC	FT	ø EL %
Professors (F / A)	589	562.8	95.6	102	97.6	95.7	691	660.4	95.6
Assistant professors with tenure track	90	90.0	100.0	32	32.0	100.0	122	122.0	100.0
Assistant professors without tenure track	35	35.0	100.0	14	13.1	93.6	49	48.1	98.2
Scientific personnel	9,345	8,094.0	86.6	4,272	3,514.0	82.3	13,617	11,608.0	85.2
of whom senior scientific personnel	684	655.3	95.8	111	99.1	89.3	795	754.4	94.9
Technical personnel	3,049	2,874.7	94.3	905	717.1	79.2	3,954	3,591.8	90.8
Administrative personnel	1,238	1,085.7	87.7	2,470	1,866.6	75.6	3,708	2,952.3	79.6
Apprentices	311	311.0	100.0	147	146.6	99.7	458	457.6	99.9
Total	**14,657**	**13,053.2**	**89.1**	**7,942**	**6,387.0**	**80.4**	**22,599**	**19,440.2**	**86.0**

Headcount (employment contracts, EC) and employment level (EL) of men, women and the entire ETH Domain by function group. As of 2010, the senior scientists, maîtres d'enseignement et de recherche (MER) and other senior personnel are counted separately, but nevertheless are still included under scientific personnel. A total of 6,234 doctoral students are enrolled at the two Federal Institutes of Technology. Of these, all who are employed in the ETH Domain are included under scientific personnel.

Fig. 19: Development in the numbers of female and male professors

	2019			2018			Changes		
	Men	Women	Total	Men	Women	Total	Men in %	Women in %	Total in %
Professors (F / A)	589	102	691	594	93	687	−0.8	9.7	0.6
Assistant professors with tenure track	90	32	122	84	24	108	7.1	33.3	13.0
Assistant professors without tenure track	35	14	49	41	15	56	−14.6	−6.7	−12.5
Total professors	**714**	**148**	**862**	**719**	**132**	**851**	**−0.7**	**12.1**	**1.3**

Change in the number of professors according to: full and associate professors, assistant professors with tenure track and assistant professors without tenure track. The three last columns show the percentage change since the previous year.

Professorial categories

The various professorial categories differ with regard to status and employment conditions. Full (F) and associate (A) professors, and assistant professors with and without tenure track (TT) teach and undertake research at both Federal Institutes of Technology. The latter can become permanently employed as full or associate professors if they meet a certain performance target. Full and associate professors are appointed permanently, while assistant professors sign employment contracts for a maximum of four years. The latter can be renewed for up to another four years.

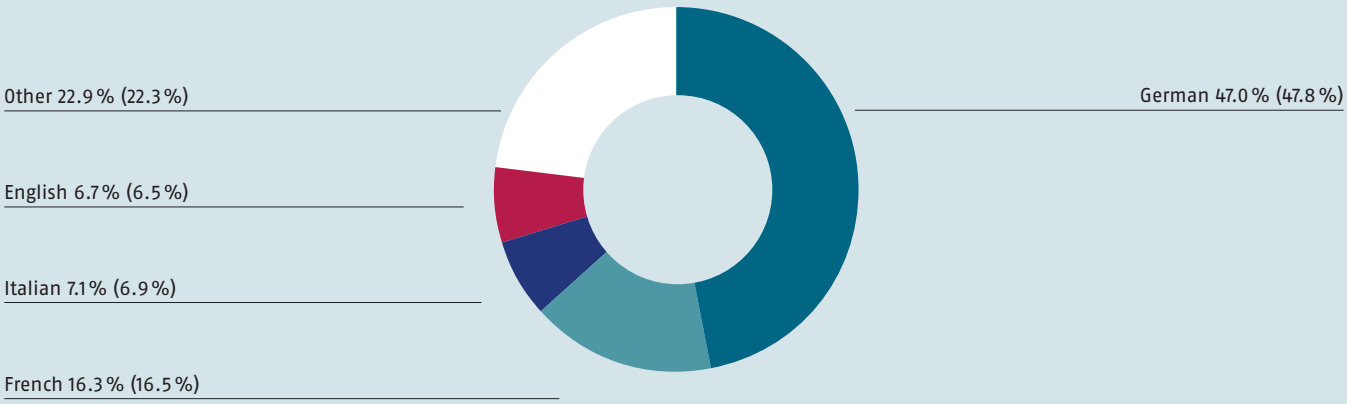
From 1 March 2017, a new provision in the ETH Ordinance concerning Professors came into force, expanding the category of full professors and regulating the framework conditions for the appointment of the affiliated professors. The embedding of the framework conditions will enable both Federal Institutes of Technology to pursue more selective and intensive cooperation with research institutions at home and abroad. On the basis of a pre-existing institutional cooperation agreement, selected individuals from domestic and foreign research institutions may be appointed as affiliated professors at one of the two Federal Institutes of Technology.

Fig. 20: Origin of male and female professors

	Switzerland			EU			Other		
2019	Men	Women	Total	Men	Women	Total	Men	Women	Total
Professors (F/A)	222	30	252	303	57	360	64	15	79
Assistant professors with tenure track	15	6	21	50	16	66	25	10	35
Assistant professors without tenure track	12	3	15	16	10	26	7	1	8
Total professors	**249**	**39**	**288**	**369**	**83**	**452**	**96**	**26**	**122**

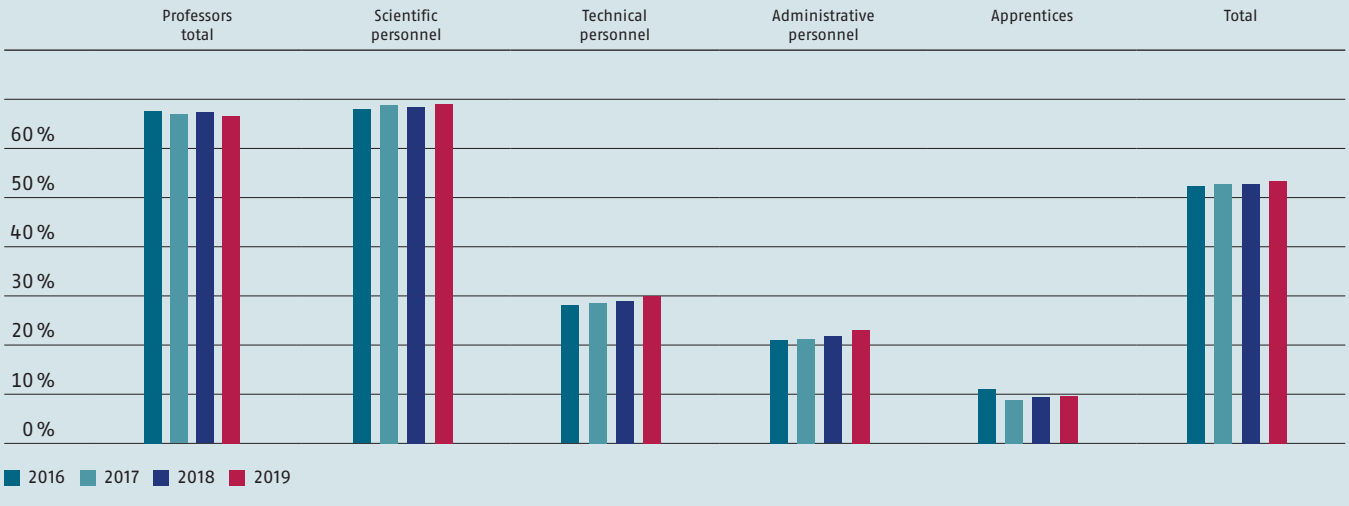
Number of professors broken down by origin: Switzerland, the EU and other countries.

Fig. 21: Employees' native languages



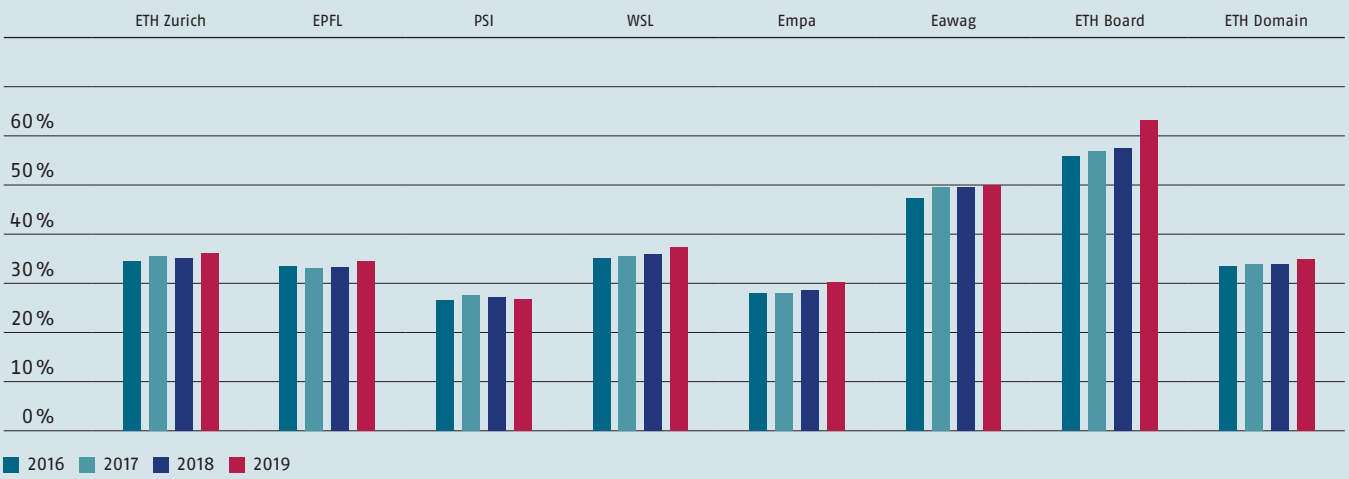
Native languages of employees in the ETH Domain in 2019. Figures for the previous years are shown in brackets.

Fig. 22: Development in the proportions of foreign employees by function group



Development in the proportions of foreign employees in ETH Domain by function group (in relation to the number of employment contracts).

Fig. 23: Development in the proportion of women by institution



Development in the proportion of women by institution over the past four years (in relation to the number of employment contracts).

Fig. 24: Source of funds by function group

Function group		Professors (all)	Scientific personnel	Technical personnel	Administrative personnel	Total
Source of funds						
Total federal contribution Federal financial contribution	2018	749.8	6,254.2	2,920.1	2,502.7	**12,426.8**
	2019	767.8	5,859.0	2,951.4	2,660.2	**12,238.4**
	Δ 2018 / 2019	18.0	–395.2	31.3	157.5	**–188.4**
Third-party resources Research funding (SNSF, Innosuisse, further), government-funded research and EU research programmes	2018	34.5	3,833.4	193.9	99.0	**4,160.8**
	2019	30.0	4,155.3	243.2	104.4	**4,532.9**
	Δ 2018 / 2019	–4.5	321.9	49.3	5.4	**372.1**
Industry-oriented research, donations / bequests	2018	33.9	1,461.9	371.9	204.0	**2,071.7**
	2019	32.5	1,596.3	395.3	187.2	**2,211.3**
	Δ 2018 / 2019	–1.4	134.4	23.4	–16.8	**139.6**
Total	2018	818.2	11,549.5	3,485.9	2,805.7	**18,659.3**
	2019	830.3	11,610.6	3,589.9	2,951.8	**18,982.6**
	Δ 2018 / 2019	12.1	61.1	104.0	146.1	**323.3**

Source of funds according to function groups (in FTEs) in 2019 compared to 2018. Δ (delta) shows the absolute change compared to the previous year. Figures exclude apprentices (457.6 FTEs) and trainees.

Real estate

Fig. 25: Source of funds for ETH Domain constructions (in CHF millions)

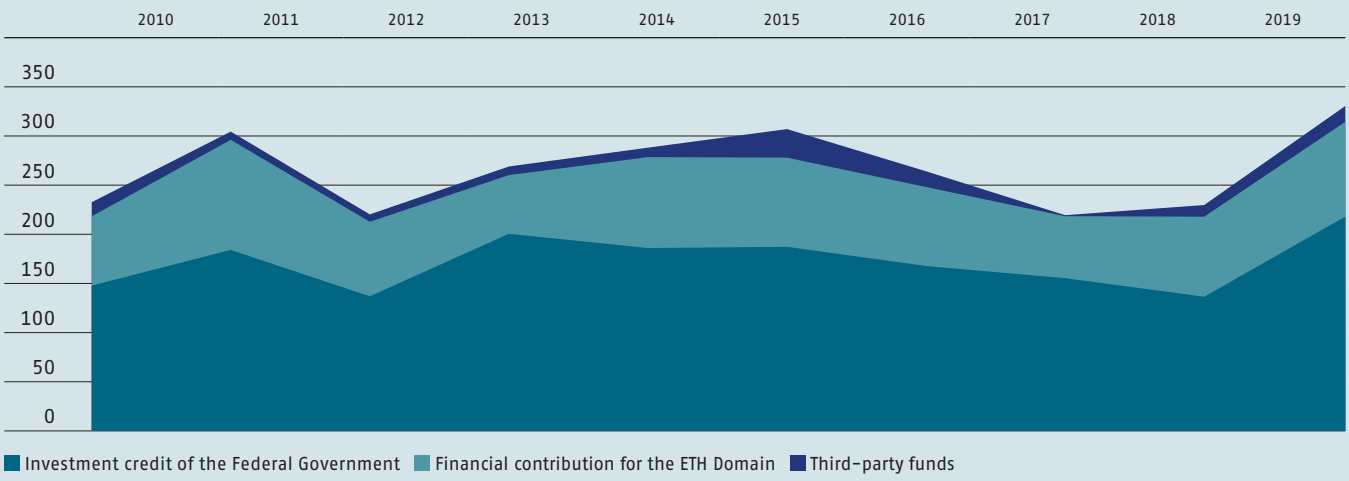
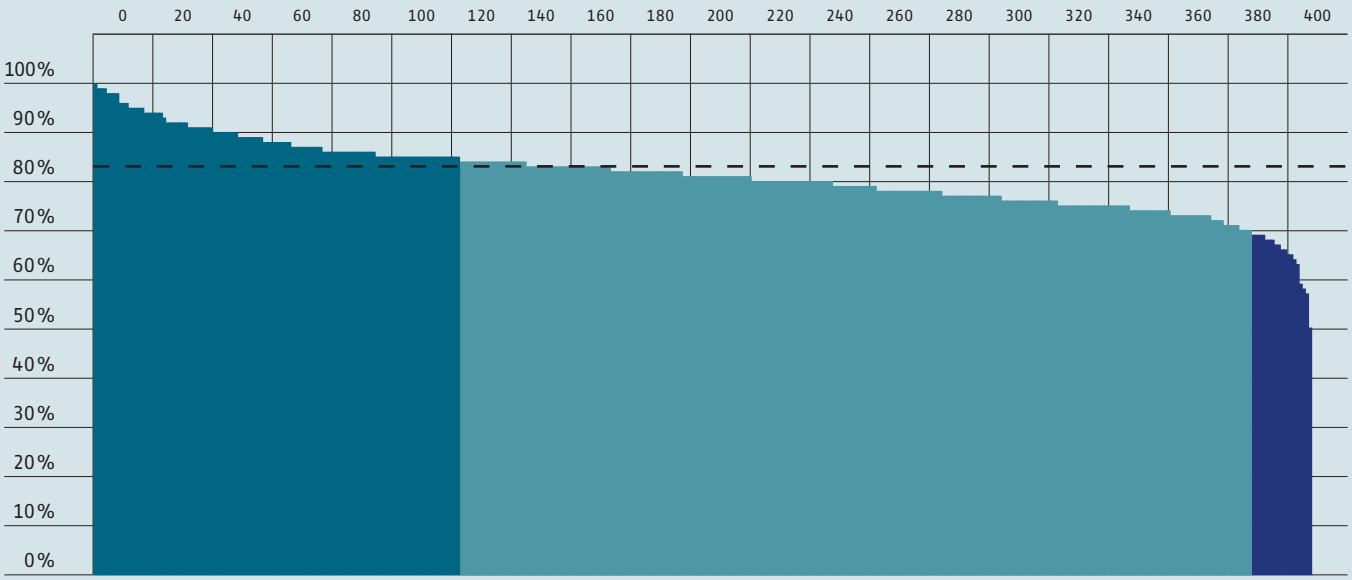


Fig. 26: Condition value as of 31 December 2019



Number of properties recorded: 389

- Very good condition, as new
- Good condition, no measures needed
- -- Average weighted by original value of properties: 83 %
- Average condition, plan and implement measures
- Poor condition, measures needed

Fig. 27: Development of the main usable area by institution in %

Fig. 28: Mix of areas (in 1,000 m²)

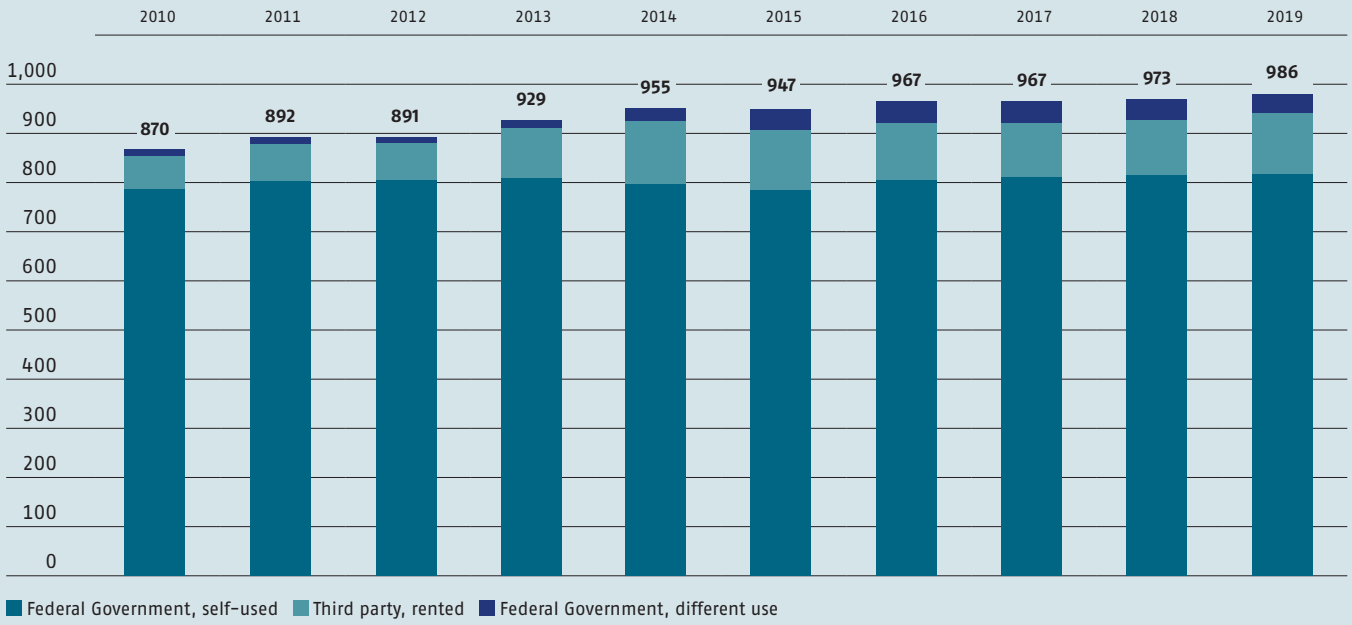


Fig. 29: Quantity structure of the ETH Domain portfolio

CHF millions	ETH Zurich	EPFL	PSI	WSL	Empa	Eawag	Total
Buildings / facilities							
Quantity	161	84	138	23	28	12	446
Original value	3,608	1,656	628	100	362	102	6,456
Carrying amount	1,325	877	230	43	95	49	2,620
Plots							
Quantity	68	19	9	15	4	4	119
Carrying amount	691	243	30	24	63	10	1,062
Carrying amount of installations under construction	312	55	13	3	9	14	407
Building rights (not valuated, in compliance with regulations)							0
Total assets (carrying amount real estate)	**2,329**	**1,175**	**273**	**70**	**167**	**74**	**4,088**
Provisions (e.g. for polluted sites, asbestos, radioactive waste)							281

Quantity and value of all government-owned real estate allocated to the institutions of the ETH Domain.

Fig. 30: Investments

CHF 1,000	ETH Zurich	EPFL	PSI	WSL	Empa	Eawag	Total
Investment credit from Federal Government	150,000	40,200	10,100	2,590	5,030	10,630	218,550
of which for new or replacement constructions	70,854	2,887	6,919	697	1,697	10,236	93,289
of which for maintenance of value and functionality	79,146	37,313	3,181	1,893	3,333	394	125,261
Financial contribution investments (for user-specific construction)	72,130	15,602	5,839	401	2,148	169	96,290
Third-party resources	10,743	3,570	0	0	1,804	0	16,117
Construction expenses of the Institutions	232,873	59,372	15,939	2,991	8,983	10,799	330,957
Main usable area (m^2)	488,220	288,380	112,410	20,080	59,850	17,380	986,320
Construction expenses per m^2 main usable area (CHF / m^2)	477	206	142	149	150	621	336

2019 investments in the ETH Domain portfolio, based on the main usable area (in m^2). This is the part of the usable area that is directly allocated to the core task of teaching and research. Because the research institutes themselves do not provide teaching, a figure for the area across the entire Domain – for example in relation to the number of students – would not be very informative.

Environment and energy

Fig. 31: Environment and energy data

		ETH Domain 2017	ETH Domain 2018	ETH Zurich Total	EPFL Total	PSI Total	WSL Total	Empa Total	Eawag Total	ETH Domain Trend 2019[1]
BASIC DATA										
Energy reference area (ERA)[2]	m²	1,475,985	1,470,019	696,191	424,390	169,650	28,246	123,442	28,100	1,459,162
Full-time equivalent[3]	FTE	36,103	37,532	21,393	11,694	2,061	670	1,021	693	38,361
ENERGY[4]										
Final energy, net[7]	**kWh / a**	**429,011,863**	**435,890,829**	**186,965,283**	**94,832,452**	**128,874,141**	**4,701,850**	**16,366,323**	**4,150,780**	**425,448,033**
Electricity, net (not incl. self-produced)	**kWh / a**	**357,484,834**	**346,882,764**	**131,332,000**	**76,073,000**	**122,208,141**	**2,853,911**	**11,004,112**	**3,411,600**	**341,695,403**
Consumption of uncertified electricity	kWh / a	50,939,413	43,870,141	1,662,000	0	42,208,141	0	0	0	
Consumption of certified electricity	kWh / a	306,545,421	303,012,623	129,670,000	76,073,000	80,000,000	2,853,911	11,004,112	3,411,600	
Electricity (without naturemade star)	kWh / a	298,164,120	293,836,779	125,670,000	73,820,000	80,000,000	876,907	13,469,872	0	
Photovoltaic naturemade star	kWh / a	2,084,150	2,085,290	0	2,000,000	0	0	0	85,290	
Hydro power naturemade star	kWh / a	13,936,394	13,954,314	4,000,000	4,751,000	0	1,877,004	0	3,326,310	
Wind naturemade star	kWh / a	101,996	100,000	0	0	0	100,000	0	0	
Sale of electricity	kWh / a	−7,741,239	−6,963,760	0	−4,498,000	0	0	−2,465,760	0	
Heat	**kWh / a**	**69,191,978**	**87,509,035**	**54,832,000**	**18,759,452**	**6,402,000**	**1,414,192**	**5,362,211**	**739,180**	
Fuel oil	kWh / a	7,918,044	8,613,209	1,445,000	6,717,000	160,000	284,859	0	6,350	
Natural gas	kWh / a	53,911,698	50,769,631	33,396,000	12,005,000	0	0	5,368,631	0	
District heating	kWh / a	33,038,081	51,884,009	43,761,000	421,769	6,242,000	0	726,410	732,830	
Woodchip	kWh / a	1,100,684	1,136,016	0	6,683	0	1,129,333	0	0	
Sale of heat	kWh / a	−26,776,529	−24,893,830	−23,770,000	−391,000	0	0	−732,830	0	
Fuels (own vehicles)	**kWh / a**	**2,335,051**	**1,499,030**	**801,283**	**0**	**264,000**	**433,747**	**0**	**0**	
Energy: additional information										
Energy costs, electricity and heat[5]	CHF / a	47,371,233	48,131,104	25,867,086	10,281,345	10,523,588	450,159	512,617	496,309	50,358,487
Self-generated renewable electricity	kWh / a	622,450	2,718,349	214,127	2,000,000	0	130,750	199,064	174,408	
Total sale to third parties	kWh / a	−34,517,768	−31,857,590	−23,770,000	−4,889,000	0	0	−3,198,590	0	
WATER (DRINKING WATER)	m³	663,418	680,576	373,355	178,559	94,115	8,095	22,234	4,218	697,160
MATERIALS										
Paper	**kg**	**344,133**	**284,909**	**179,300**	**54,500**	**28,521**	**6,256**	**10,857**	**5,475**	**239,706**
Paper, new fibre	kg	114,284	82,817	31,800	40,400	9,361	1,036	100	120	76,520
Paper, recycled	kg	229,849	202,092	147,500	14,100	19,160	5,220	10,757	5,355	163,186
KEY FIGURES: ENVIRONMENTAL IMPACT										
Primary energy[6]	**kWh / a**	**597,739,400**	**587,599,808**	**211,080,341**	**115,711,876**	**228,539,959**	**7,205,870**	**19,710,995**	**5,350,768**	
Proportion of renewable energies	**%**	**68**	**65**	**58**	**65**	**75**	**55**	**66**	**76**	
CO_2 emissions	**t CO_2 / a**	**35,553**	**36,630**	**16,892**	**7,763**	**9,702**	**411**	**1,553**	**309**	

1 Provisional figures for the reporting year (trend), as at: start of March 2020.
2 The energy reference area is the sum of all gross floor areas, above and below ground, which must be heated or air-conditioned in order to be used.
3 The FTE (full-time equivalent) value listed here was supplemented by the number of students with an FTE value of 0.68 to produce the consumption per person.
4 The key figures indicated for electricity and heat show the total consumption of both for buildings, as well as for teaching and research activities.
5 The key indicator "energy costs" shows all expenditure (cash out) for the provision of energy (heat and electricity).
6 In energy economics, one refers to primary energy as the energy that is available using the original forms or resources of energy, such as fuel (e. g. coal or natural gas), as well as energy carriers such as sun, wind or nuclear fuels.
7 Final energy is the portion of the primary energy that is left after losses due to energy conversion and transmission, after it is supplied via the consumer's domestic connection. The final energy basically corresponds to the energy that is purchased.

FINANCES

* Extract of the Financial Report 2019

Financial report:
www.ethboard.ch/financialreport2019

Financing statement

The main share of the ETH Domain's financing comes from the Federal Government. Brisk construction activity in 2019 resulted in high expenses.

Financing
The ETH Domain's operating revenue in 2019 was slightly up on the 2018 figure (2019: CHF 3,591m; 2018: CHF 3,571m). Expectations according to the 2019 budget were met (CHF 3,589m including the increase). At the time the 2019 budget report was prepared, the increase of CHF 30.0m in the total federal contribution (in accordance with federal decree (FedD) BB Ia for the 2019 budget) had not yet been decided on in terms of revenue and is, therefore, not factored into the total revenue as yet. Compared to the previous year, there was a slight shift in the proportions in favour of the total federal contribution but overall the proportions have remained very stable over the years. By far the largest part of the funding comes from the total federal contribution.

Source of funds
As the owner, the Federal Government accounts for almost 90% of funding (2019: 87%). In 2019, it contributed 71.9% available directly through the total federal contribution and a further 15.1% indirectly through research contributions. The share of third-party funding was down as a percentage of operating revenue and amounted to 11.7% (2018: 13.1%). At CHF 419.7m, the total amount was also lower than in 2018 (CHF 469.3m). The higher semester fees and the increase in student numbers had a bearing on the total revenue (2019 statement: CHF 48m; 2018 statement: CHF 41m).

Monitoring sets out the credits approved in accordance with FeD Ia for the budget. By contrast, expenditure is reported in the accounts (volume 2 B). In the case of 2018 and 2019, this has led to discrepancies in the values for the ETH Domain investment credit for buildings (credit A202.0134) between the ETH Board's Annual Report for the ETH Domain and the 2018 and 2019 accounts.

Total federal contribution
The maximum approved expenditure ceiling for the ETH Domain for the period from 2017 to 2020 amounts to CHF10,337.8m (Ø annual growth: 1.9%). Utilisation is 99% at the end of the 2017–2020 performance period (CHF 10,239.0m). This results in an average annual growth rate of 1.4% (see Figs. 1 and 2, p. 70).

Credits taking into account the expenditure ceiling
The total of the two loans approved by the Federal Assembly in FedD BB Ia for the 2019 budget, credited against the expenditure ceiling, amounted to CHF 2,581.2m. Compared with 2018 (2018 budget: CHF 2,530.9m), the increase was CHF 50.3m (+2.0%). The rise also includes the increase of CHF 30.0m compared to the proposal under the FedD by the Federal Assembly (August 2018). The ETH Board allocated this increase to the base budget for 2020 instead of 2019. In 2019, there was another credit shift (CHF 7.2m) in favour of the federal financial contribution. Of the reserves of CHF 40.0m set aside in the Confederation as parent entity in accordance with Section 32a of the Federal Financial Budget Act (FBA) (see 2018 state financial statements), CHF 10m were used in 2019 in accordance with Section 35 FBA. In the 2019 accounts, this appropriation is recognised as a reversal by way of exceeding the overdraft at the Federal Office for Buildings and Logistics (FBL) (VE 620) for credit A202.0134 Buildings in the ETH Domain. The total also includes the funds for tasks from the "Digitalisation Action Plan".

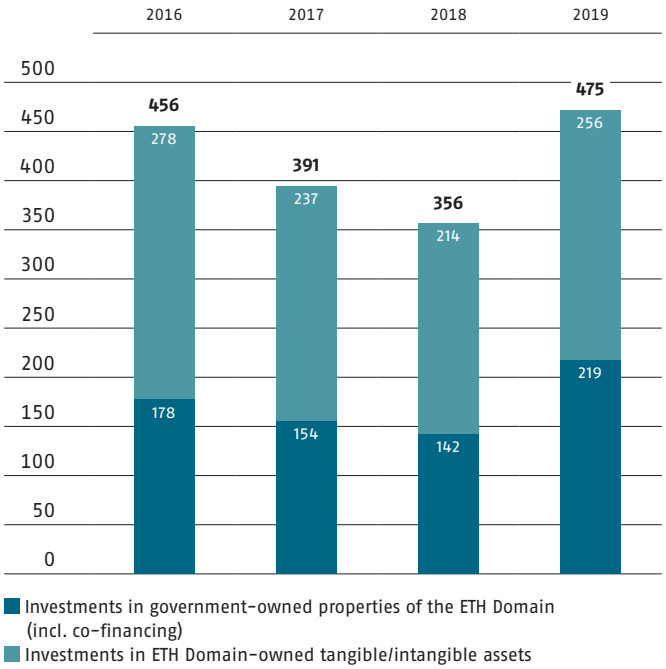
Research contributions of the Federal Government and the EU
In 2019, the Federal Government contributed a total of CHF 543m via its two main funding agencies SNSF and Innosuisse, as well as via special federal funding of applied research and funding from EU FPs to fund the ETH Domain. Revenue exceeded the previous year's total for 2018 (2018 statement: CHF 533m), but was

slightly down on the budgeted figure (2019 budget: CHF 553m). With the exception of the downturn in revenue from innovation projects of the funding agency Innosuisse, all categories of special federal funding of applied research were up on 2018; in particular, the funds from the 8th EU FP (2014–2020) showed a clear rise. For the above-mentioned reasons, there were slight shifts in the proportions of research contributions of the Federal Government and the EU. However, research contributions of the Federal Government measured as a percentage of total financing in 2019 remained unchanged from the previous year at around 15%.

Research contributions by third parties/ various revenue

Total operating revenue of CHF 420m in 2019 was substantially (-CHF49.6m) below the previous year's figure for 2018 (CHF 469m). Nevertheless, the figure was slightly higher than had been expected (2019 budget: CHF 414 million). The decline compared with 2018 is exclusively due to the recognised donations from ETH Zurich, the total of which more than halved (-CHF 72 m) due to the lower number of contracts. Although the decline was partially absorbed or compensated for by higher revenue from cooperation with the private sector and the cantons and by higher revenue from other income streams, the share of research contributions by third parties/various revenue, measured against the total financing, fell compared to the previous year, 2018, from 13% to just under 12%.

Fig. 32: Development of the total investments (in CHF millions)



Note: The operating revenue from research contributions and from other operating revenue does not normally equate to the operating revenue in the statement of financial performance. However, the distinction between the two, which is actually necessary, is not practicable. Consequently, identical values are shown in the transition from the financing statement to the statement of financial performance. In general, the development of research contributions must be assessed on the basis of the balance sheet and the federal funding allocated (SNSF and Innosuisse, special federal funding of applied research, EU FPs).

Allocation of funds (expenses)

The total operating expenses in 2019 amounted to CHF 3,489m. It exceeds the previous year's figure (2018: CHF 3,349m). However, the approved budget was not met (2019: CHF 3,635m including the increase in accordance with FedD BB Ia on the budget for 2019). Compared to 2018, it was primarily the sharp rise in investments that contributed to the increase in expenses. A further part of the additional expenditure was attributable to higher personnel expenses. In total, additional expenditure of around CHF 140m was incurred. Current operating expenses were clearly overbudgeted; this was also the main reason for the budget shortfall compared with the 2019 budget.

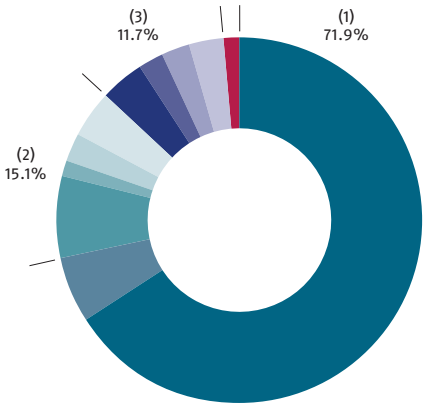
Expenses can be split into expenses on personnel, on property, plant and equipment, and on investments. Personnel account for the main share of the expenses (2019: 65.5%; 2018: 66.6%). In 2019, investments in property, plant and equipment accounted for almost 14% of the total expenses (2018: 10.9%). The level of the other current operating expenses (2019: 20.9%) for infrastructure and for projects in teaching and research depends upon a number of factors (refer to the Financial Report at www.ethboard.ch/financialreport2019).

The pro rata distribution of the main components of expenses in the 2019 reporting period shows a slight shift compared with the previous year away from current expenses to a higher proportion of investments (Utilisation perspective).

Personnel

The total of CHF 2,282m was CHF 50m higher than in the previous year (2018 statement: CHF 2,232m). In the reporting period, 18,982.6 full-time equivalents (FTEs; reporting date values) were financed, spread over 22,599 employment contracts (2018: 18,659.3 FTEs). The additional expenditure on personnel was primarily a direct result of financing the additional posts (+323,3 FTEs). Part of the additional personnel expenses was used to compensate for inflation, to manage the payroll system and to increase employer contributions.

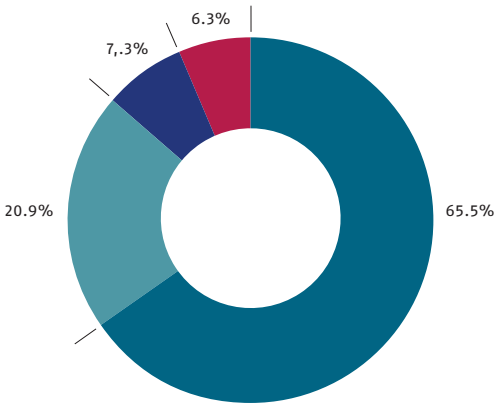
The bulk of the full-time equivalents is accounted for by the total federal contribution (2019: 12,238.4 FTEs), for which, according to the statistical survey, almost



Source of funds
Fig. 33*: Structure of revenue in %

Operating revenue, 2019 statement: CHF 3,591m
(Financing statement perspective)

(1) Total federal contribution (expenditure ceiling perspective)	**71.9%**
Federal financial contribution	66.0%
Investment credit for ETH Domain constructions	5.8%
(2) Research contributions of the Federal Government and the EU	**15.1%**
Swiss National Science Foundation (SNSF)	7.2%
Innosuisse	1.4%
Special federal funding of applied research	2.3%
EU Framework Programmes for Research and Innovation (FP)	4.2%
(3) Third-party funds	**11.7%**
Cooperation with industry	4.1%
Other third-party funds (universities, cantons, etc.)	2.0%
Donations and bequests	2.6%
Other revenue	3.0%
Tuition fees, continuing education	1.3%



Use of funds
Fig. 34**: Structure of expenses in %

Operating expenses, 2019 statement: CHF 3,489m
(Financing statement perspective)

Personnel	65.5%
Other expenses	20.9%
Investments in ETH Domain-owned properties	7.3%
Investments in government-owned properties	6.3%

* Fig. 33 shows the revenues from the perspective of financing by source of funds. They amount to CHF 3,591m and comprise the following: Federal financial contribution; investment credit for buildings of the ETH Domain; donations and bequests; research contributions, mandates and scientific services; school fees and other utilisation fees; other revenues.

** Fig. 34 shows the expenses from the perspective of financing after allocation of funds. They amount to CHF 3,489m and comprise the following: Personnel expenses (after adjustment to the net pension costs in accordance with IPSAS 39); investments in government-owned buildings; investments in property, plan and equipment and intangible assets owned by the ETH Domain; other operating expenses (excluding accommodation expenses); transfer expenses. Depreciation is not part of the total after allocation of funds.

CHF 1,700m was spent in 2019 and is charged to the federal financial contribution. The number of full-time equivalents financed by the total federal contribution fell by 188.4 compared with 2018. The research contributions of the Federal Government and the EU financed 4,532.9 FTEs, and 2,211.3 FTEs were financed in cooperation with the private sector and from donations / bequests. Compared with 2018, there was a particular increase in full-time equivalents financed by research contributions of the Federal Government and the EU (+372.1 FTEs and +8.9% respectively).

The employer's contributions in relation to salaries and wages (not allowing for IPSAS 39) stood at 20.5% in 2019 (2018 statement: 19.9%). The 2019 budget calculations included a flat-rate employer contribution of 21.4% in line with Federal Government practice (Federal Office of Personnel, FOPER). The effective contribution rate for 2019 was lower than the contribution rate used for the calculation.

Investments
Significantly more was invested in 2019 than in 2018 (2019: CHF 475m; 2018: CHF 356m). The hike in expenses (+CHF 119m) is attributable without exception to the high level of construction activity in the reporting period. All investments are shown under the total investments, irrespective of ownership and their financing, i.e. they are the investments in the property used by the ETH Domain. For this reason, investments in real estate owned by the Federal Government are also included in the total investments, even though these are financed by the A202.0134 Investment credit for buildings in the ETH Domain, which is located at the Federal Office for Buildings and Logistics (FBL) (VE 620 Confederation as parent entity).

The share of total investments, measured as a proportion of total expenses, was slightly above the long-term average (approx. 12%), but within the usual range compared, for example, with the central federal ad-

ministration (12–15% share of total expenses). The largest investments in terms of amount related to the generally high investment expenses for leasehold improvements (building costs plan 3) – above all at ETH Zurich – and, as in the previous year, the investments in the ATHOS beamline at the PSI.

Transition from the financing statement to the statement of financial performance

From a financing perspective, the money from the total federal contribution is allocated to the period in which the funds are provided. From this point of view, therefore, the total federal contribution is made up of the credits offset against the ETH Domain's expenditure ceiling: A231.0181 federal financial contribution to the ETH Domain and A202.0134 buildings in the ETH Domain. However, they are recognised in the statement of financial performance on an accrual basis. Therefore, from the point of view of the statement of financial performance, the total federal contribution consists of the following credits: A231.0181 federal financial contribution to the ETH Domain and A231.0182 federal contribution to accommodation in the ETH Domain.

The different views require a reconciliation of the operating revenue (2019: CHF 3,591m) to the consolidated operating revenue of the ETH Domain as per the statement of financial performance (2019: CHF 3,675m). Therefore, analogous figures must be shown.

The main differences between total expenses (2019: CHF 3,489m) according to the financing statement and operating expenses (2019: CHF 3,637m) according to the statement of financial performance are as follows: investments are only included in expenses. By contrast, accommodation and depreciation merely represent expenses. Other aspects of the reconciliation relate to the net pension costs according to IPSAS 39 and the effect of the sub-consolidation of ETH Zurich and EPFL. Both transactions are generally not taken into account in budgeting or in the financing statement and are part of the reconciliation. This also applies to in-kind contributions from donated rights.

Fig. 35: Transition from the financing statement to the statement of financial performance

	Financing statement	Transition			Statement of financial performance
CHF millions	2019	Decrease (–)	Increase (+)	Consolidation (+ / –)	2019
FINANCING STATEMENT / STATEMENT OF FINANCING PERFORMANCE					
Income (source of funds) / Operating revenue	**3,591**	**–209**	**244**	**48**	**3,675**
Total federal contribution	**2,581**	**–209**	**244**	**–**	**2,616**
Federal financial contribution	2,373				2,373
Investments in constructions of the ETH Domain	209	–209			–
Federal contribution to accommodation	–		244		244
Tuition fees, continuing education	48				48
Special federal funding of applied research	543				543
Special third-party funding of applied research	219			16	235
Various income	200			32	232
Expenses (allocation of funds) / Operating expenses	**3,489**	**–219**	**578**	**44**	**3,637**
Personnel expenses	2,284		82	20	2,386
Other operating expenses / accommodation ETH Domain	–		244		244
Depreciation	–		252	14	267
Other ongoing operating and transfer expenses	731			10	740
Investments	**474**	**–219**	**–**	**–**	**256**
Government-owned properties ETH Domain	219	–219			–
Co-financing government-owned properties ETH Domain	–				–
Immovable property, plant and equipment (ETH Domain-owned)	85				85
Movable non-current assets (ETH Domain-owned)	169				169
Intangible non-current assets (ETH Domain-owned)	2				2

Financing statement view – revenue/expenditure and statement of financial performance view – expense/revenue

Consolidated financial statements

Table 1: Statement of financial performance of the ETH Domain (consolidated)

CHF millions	Notes	Budget 2019	Actual 2019	Actual 2018	Change to Actual absolute
Federal financial contribution		2,373	2,373	2,357	16
Federal contribution to accommodation		244	244	269	–25
Total federal contribution	7	**2,616**	**2,616**	**2,625**	**–9**
Tuition fees, continuing education	8	**41**	**48**	**41**	**7**
Swiss National Science Foundation (SNSF)		261	260	255	5
Swiss Innovation Agency (Innosuisse)		68	49	56	–6
Special federal funding of applied research		79	82	81	1
EU Framework Programmes for Research and Innovation (FP)		144	152	142	10
Industryoriented research (private sector)		132	146	139	7
Other project-oriented third-party funding (incl. cantons, municipalities, international organisations)		71	90	84	7
Research contributions, mandates and scientific services	9	**756**	**779**	**755**	**24**
Donations and bequests	10	**95**	**92**	**155**	**–63**
Other revenue	11	**115**	**140**	**138**	**3**
Operating revenue		**3,624**	**3,676**	**3,714**	**–38**
Personnel expenses	12, 28	2,352	2,386	2,333	54
Other operating expenses	13	962	935	990	–55
Depreciation	21, 23	241	267	266	1
Transfer expenses	14	173	49	43	7
Operating expenses		**3,727**	**3,637**	**3,631**	**6**
OPERATING RESULT		**–104**	**39**	**83**	**–44**
NET FINANCE INCOME / EXPENSE	15	**9**	**28**	**–22**	**50**
Share of surplus / deficit of associated entities and joint ventures	20	–	74	–11	85
SURPLUS (+) OR DEFICIT (–)		**–95**	**140**	**50**	**90**

Table 2: Balance sheet of the ETH Domain (consolidated)

CHF millions	Notes	31.12.2019	31.12.2018	Change absolute
CURRENT ASSETS				
Cash and cash equivalents	16	950	852	98
Current receivables from non-exchange transactions	17	612	558	54
Current receivables from exchange transactions	17	48	36	12
Current financial assets and loans	22	1,430	1,409	21
Inventories	18	10	10	–
Prepaid expenses and accrued income	19	49	48	1
Total current assets		**3,099**	**2,913**	**187**
NON-CURRENT ASSETS				
Property, plant and equipment	21	1,898	2,023	–125
Intangible assets	21	63	67	–4
Non-current receivables from non-exchange transactions	17	939	970	–31
Non-current receivables from exchange transactions	17	–	–	–
Investments in associated entities and joint ventures	20	208	135	73
Non-current financial assets and loans	22	42	32	10
Co-financing	23	123	128	–4
Total non-current assets		**3,272**	**3,354**	**–82**
TOTAL ASSETS		**6,371**	**6,267**	**104**
LIABILITIES				
Current liabilities	24	154	179	–25
Current financial liabilities	25	15	16	–2
Accrued expenses and deferred income	26	150	142	8
Short-term provisions	27	102	109	–7
Short-term liabilities		**421**	**446**	**–25**
Dedicated third-party funds	29	1,555	1,510	45
Non-current financial liabilities	25	350	361	–11
Net defined benefit liabilities	28	2,423	2,239	185
Long-term provisions	27	621	705	–83
Long-term liabilities		**4,950**	**4,815**	**135**
Total liabilities		**5,370**	**5,261**	**110**
EQUITY				
Valuation reserves		–1,470	–1,364	–106
Dedicated reserves		1,365	1,123	242
Free reserves		856	967	–110
Co-financing	23	123	128	–4
Reserves from associated entities	20	208	135	73
Accumulated surplus (+) / deficit (-)		–82	17	–99
Total equity		**1,001**	**1,006**	**–5**
TOTAL LIABILITIES AND EQUITY		**6,371**	**6,267**	**104**

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Rounding differences: The financial totals or figures presented in this document may not correspond precisely to the amounts shown in the tables. These amounts are calculated on the basis of non-rounded figures and may differ from a value based on rounded figures shown in the tables.

Special thanks are due to the following people for their contributions and involvement:
- all scientists in the ETH Domain's institutions in the preparation of the reports,
- the members of the ISP Group of the ETH Domain (Implementation of Strategic Planning),
- the members of the ETH Domain ComTeam (Heads of Communication and their staff),
- as well as the departmental heads and employees of the ETH Board staff and of the institutions of the ETH Domain.

Cover page

Milestone in the development of alternatives to animal trials: Prof. Dr Kristin Schirmer (in the photo) and her colleague Melanie Fischer were presented with the 3RCC's 3Rs Award in 2019 in recognition of their exceptional research work.

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