



3rd edition

SWISS CLEANTECH REPORT 



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Federal Office of Energy SFOE



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Switzerland is punching above its weight when it comes to climate protection initiatives worldwide



Internationally, Switzerland is known for more than chocolate and banks. It also has a reputation for innovation, in particular for developing a host of new clean and efficient technologies, some of which have been inspired by ‘madcap’ projects such as Solar Impulse, PlanetSolar and SolarStratos.

So, where does Switzerland score highly when it comes to innovation? This country offers a unique and particularly fertile environment of start-ups, SMEs, universities and cutting-edge research laboratories that attract a great deal of talent and investment. And being a small country makes it easier for the different players in innovative industries to network, creating synergies that are likely to be more effective than those in some of the world’s larger regions.

Of course, Switzerland cannot solve the problems of climate change all by itself, but it can play an exemplary role, in particular by becoming energy self-sufficient by 2050. This opportunity to serve as a model for an effective and rapid energy transition is firmly backed by the technologies developed through the country’s fabric of businesses and research laboratories.

These innovative technologies are one of the most effective ways of decarbonising the economy, in a world where we have no choice but to stop using certain resources. Replacing old polluting infrastructures with modern installations – which are not just clean and efficient but also becoming increasingly profitable – is the way industry will inevitably go this century. Introducing these technologies is logical as well as ecological.

That these clean, efficient technologies make economic sense is indisputable. They also represent a wealth of export opportunities to protect the environment and biodiversity far beyond the Swiss borders. Switzerland is thus punching above its weight when it comes to climate protection initiatives worldwide.

Our planet will always be there, but we are endangering the world we live in. The current climate problems offer us the opportunity to create a more environmentally and biodiversity-friendly future. And the clean technologies being developed in Switzerland are helping us all to meet this challenge.

Bertrand Piccard and Raphaël Domjan



© iStock - Grivina

Switzerland's cleantech credentials

Crystal-clear mountain lakes, fresh country air, lush green forests, majestic alpine peaks cloaked in everlasting snow, stunning azure skies... Switzerland lays claim to countless picture-postcard clichés. But beyond this idealised picture, the country is committed to concrete initiatives designed to safeguard its environment and resources. Swiss legislation is often exemplary, leading the way in this respect. From day to day, ordinary people, politicians, academic institutions and businesses work together to improve the way they manage the environment and bring about the energy transition designed to net zero greenhouse gas emissions in the long term. Respect for, and protection of, the environment are part of every Swiss citizen's DNA.

The purpose of this publication is to showcase the creativity and efforts being rolled out by Swiss industry to overcome the challenges presented by climate change, in particular through transitions in energy use,

the environment and digital technology. Here, we tell the story of the technological innovations and concrete solutions that have been developed in specific fields, from waste management to energy systems, mobility to smart agriculture, new materials to eco-friendly technologies and urban solutions. These efforts have something in common: they all contribute to making progress and creating a better future for the generations to come. This third edition of the Swiss Cleantech Report is an overview of Switzerland's cleantech credentials, citing concrete examples to demonstrate that Switzerland is a bona fide cleantech nation that lives by its values and can be a source of inspiration for other regions and countries around the world.

WHAT IS CLEANTECH ?

CLEANTECH REFERS TO THE TECHNOLOGIES, TECHNIQUES AND SERVICES THAT ENABLE US TO EXPLOIT AND USE NATURAL RESOURCES IN MORE EFFICIENT WAYS.

It involves an extremely diverse range of products, services and processes developed not just to provide superior performance at lower cost but also to reduce - or even eliminate - their negative impact on the environment. And all this must of course be achieved while consuming our planet's natural resources in a more responsible way. It is important to realise that cleantech is about much more than simply using technology. It also encompasses all those activities and services that raise awareness of environmental issues and bring about direct action to safeguard the environment and preserve our natural resources. Societal and behavioural aspects are therefore playing an increasingly important role, supported by digital technology and the mobile apps that facilitate access to and the processing and distribution of specific data.



“Today, digital technology causes around 4% of global greenhouse gas emissions, up to 14% by 2030. Low-power electronic devices – the legacy of our watchmaking tradition – can drastically limit this rise.”

Georges Kotrotsios

Vice President Marketing and Business Development,
Member of Executive Board of CSEM

Switzerland's economic fabric is unusual in that it is largely made up of small and medium-sized enterprises (SMEs). The cleantech sector is no exception, although it is supported by a handful of major industrial groups such as ABB, Georg Fischer, Gurit, Burckhardt Compression or Huber+Suhner. Promising start-ups including Bestmile, eSMART, Batttrion, Urbio, Hades, Flisom, Solaxess, DePoly, Energy Vault, Insolight and many others are emerging from the Federal Institutes of Technology in Zurich and Lausanne and other leading research institutes such as CSEM, Empa, PSI, eawag and the Universities of Applied Sciences and Arts (UAS).

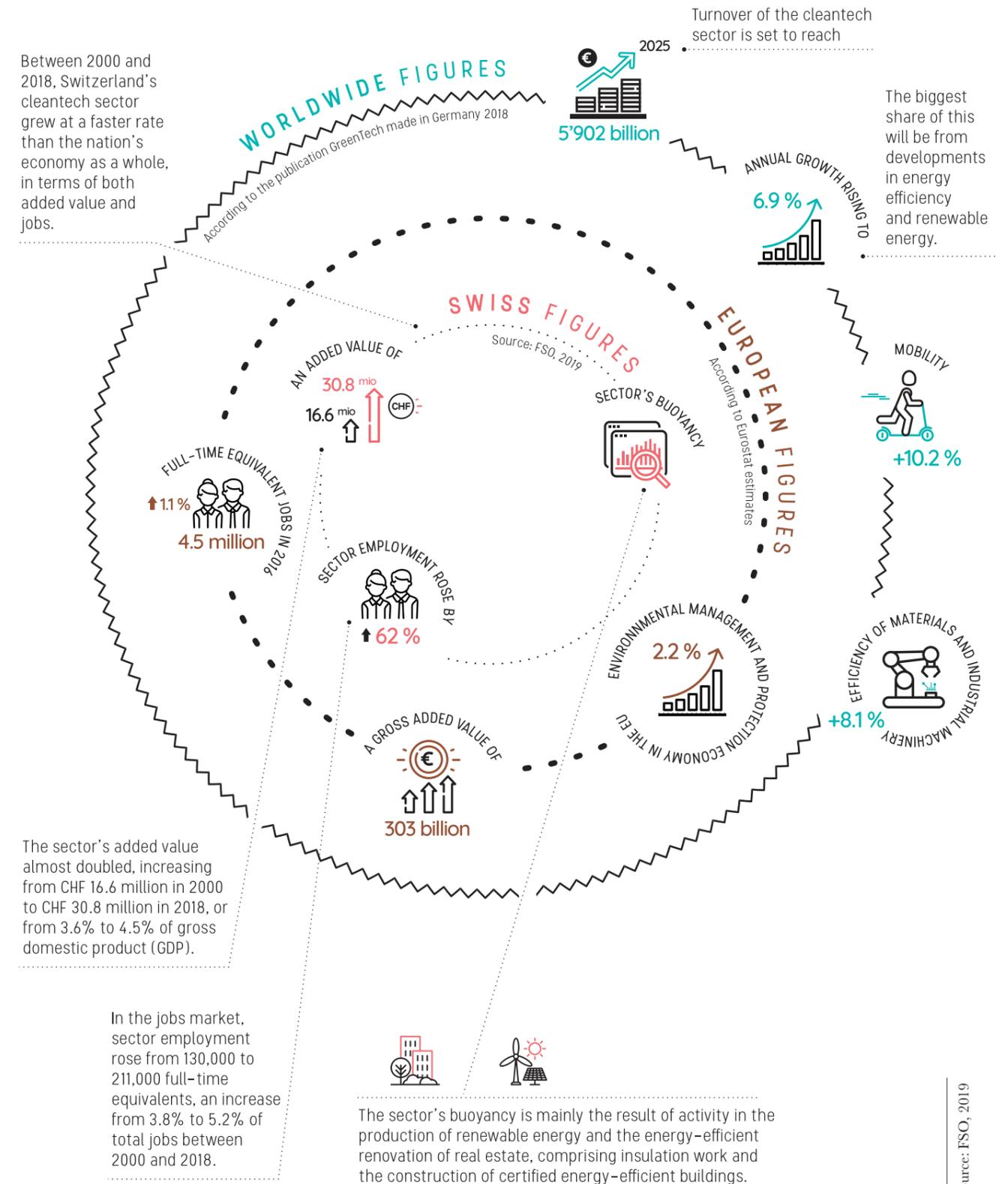


“In the face of the challenges posed by climate change, science, industry, politics and civil society must unite. Universities play a crucial role in finding technological solutions for a more sustainable world.”

Joël Mesot

President of ETH Zurich

Cleantech's key figures



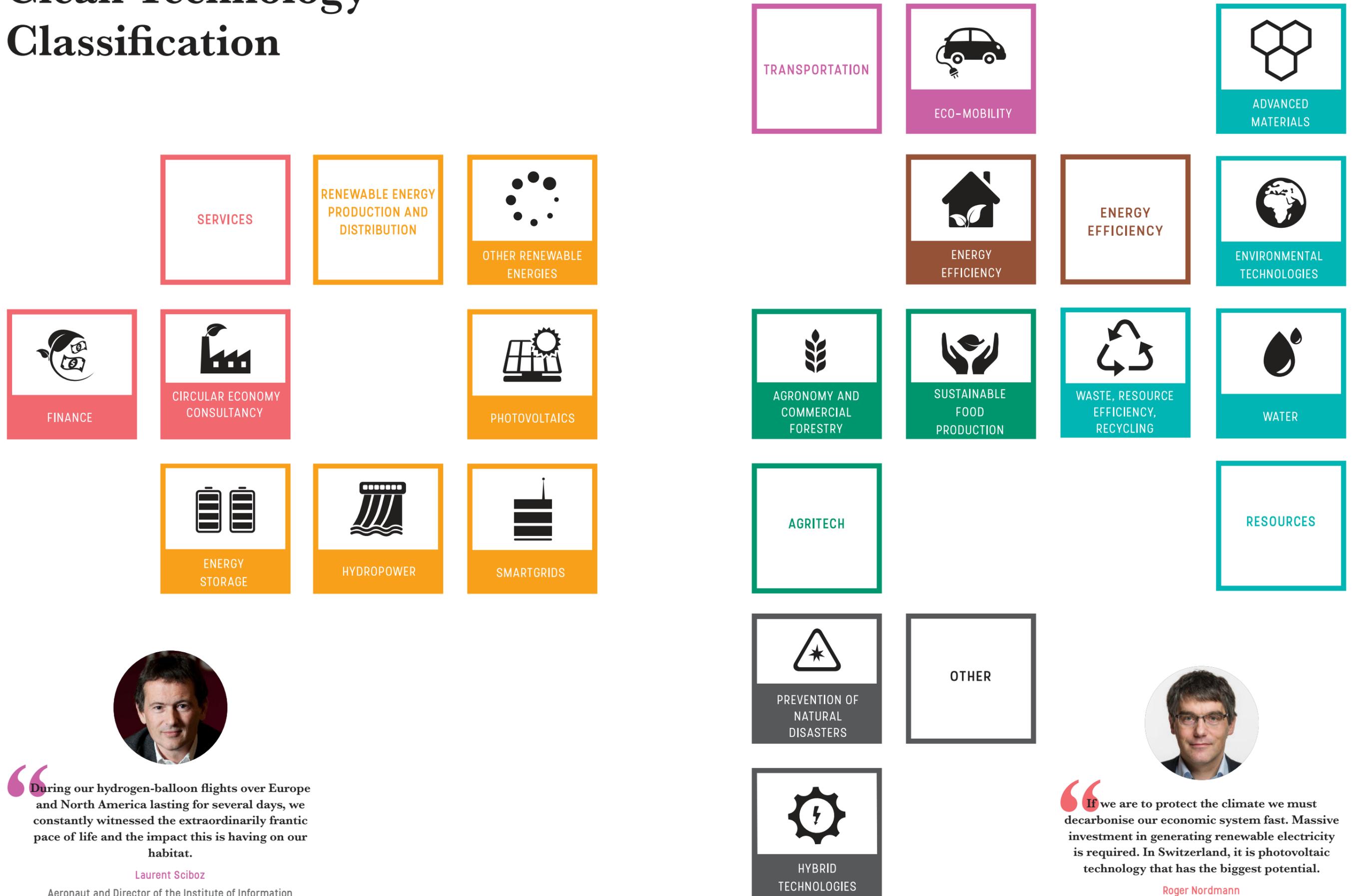


SWITZERLAND, A LEADING LIGHT IN THE ENVIRONMENTAL SECTOR

The innovative, pioneering environmental protection policies introduced in the 1980s formed a bedrock that today makes Switzerland one of the world leaders in the development of cleantech products and services. Indeed, Switzerland was the first European country to enact an environmental protection law, as far back as 1983... The effects of this forward-thinking legislative framework can be seen every day, for example in the quality of water in Switzerland's springs and rivers (not always the best quality in the past), and in the country's well-established waste recycling channels, involving a waste sorting concept embraced by the Swiss population.

Because of its capacity for technological innovation and production, Switzerland is among the world leaders in transport networks, generation of electricity from renewable sources and energy efficiency.

Clean Technology Classification



© Isabelle Favre



“During our hydrogen-balloon flights over Europe and North America lasting for several days, we constantly witnessed the extraordinarily frantic pace of life and the impact this is having on our habitat.

Laurent Sciboz

Aeronaut and Director of the Institute of Information Systems | HES-SO Valais-Wallis



“If we are to protect the climate we must decarbonise our economic system fast. Massive investment in generating renewable electricity is required. In Switzerland, it is photovoltaic technology that has the biggest potential.

Roger Nordmann

Member of the Swiss National Council

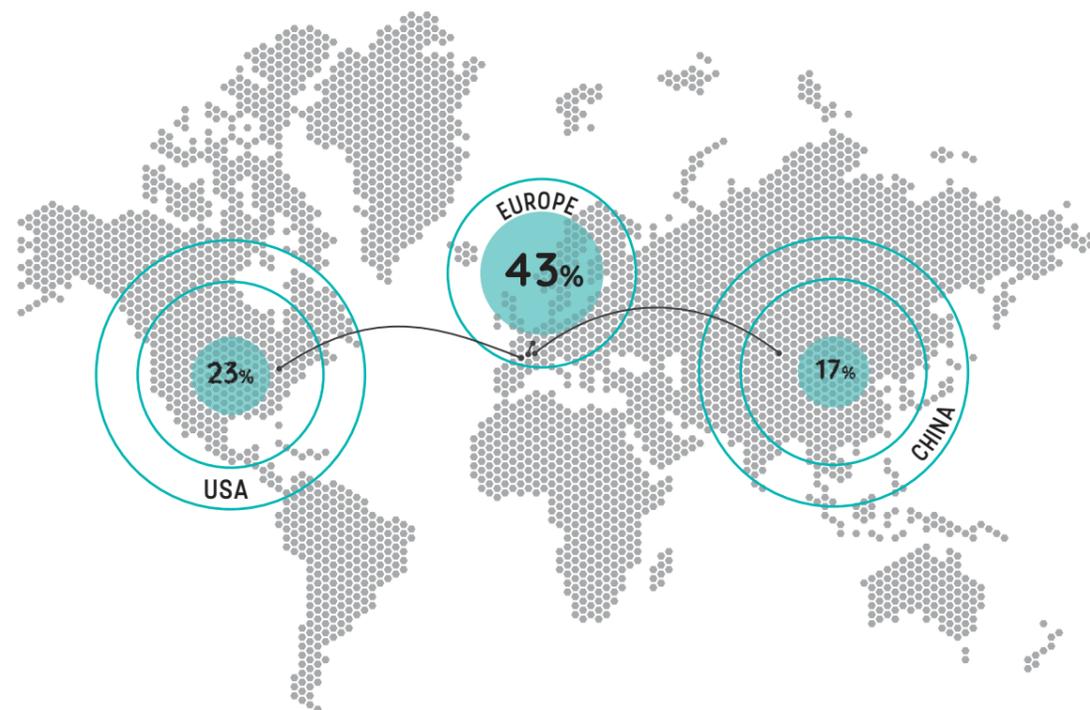
The start-up landscape in Switzerland

A country's dynamism can be measured in different ways. The number of new companies being established, in particular innovative start-ups, is a good barometer of its level of innovation. Below are a few facts about fledgling Swiss cleantech businesses.

CLEANTECH START-UPS' KEY FIGURES



EXPORT TARGETS FOR SWISS CLEANTECH START-UPS



Sources: An overview of cleantech start-ups - CleantechAlps /eqlosion 2017/Innovation Monitor 2020

BOOM YEARS FOR START-UPS



Twice as many start-ups were established per annum

2011	+50%
2006/2010	



and this was followed by a second increase

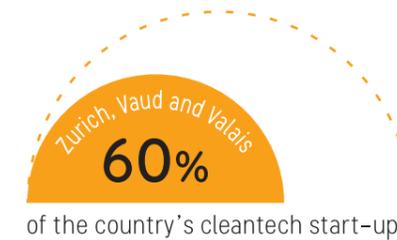
2017	+30%
2012/2016	

LEADING REGIONS



Two centres are particularly prolific when it comes to nurturing cleantech start-ups.

Zurich and Lausanne, the two Swiss cities home to the country's Federal Institutes of Technology



CLEANTECH START-UPS IN SWITZERLAND



25%



In the Swiss cleantech industry as a whole, the **resources management** sector features the largest number of start-ups, boasting more than a quarter of all newly established businesses.



20%



The 'other cleantech' sector (including **hybrid technologies**) is growing, and accounts for nearly 20% of the number of start-ups. This growth is due in particular to the rise of digital technology and the Internet of Things.



33%



The **renewable energies** and **mobility** sectors comprise a third of start-ups.



2016



x2

2019



Digital tech is also making an impact in the **services** sector, which - despite accounting for a small number of companies overall - has more than doubled in three years (2016-2019).



2016



x2

2019



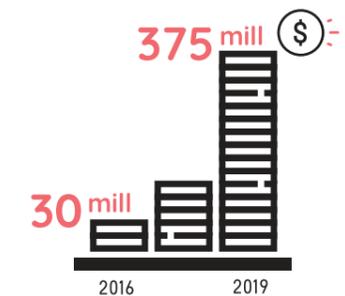
The **agritech** and **energy efficiency** sectors have also seen their numbers of start-ups double in three years (2016-2019).

Source: CleantechAlps

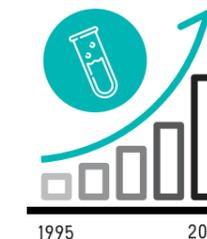
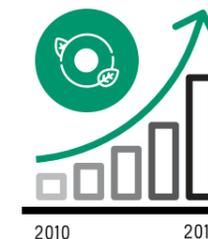
INVESTMENTS



Funds raised between 2006 and 2016 totalled around 200 million Swiss francs (not including mergers and acquisitions or bankruptcies).



In 2016, a total of 30 million dollars was raised, and in 2019 this figure was 375 million.



The investment curve in Swiss cleantech businesses is similar to that seen in biotech 10 to 15 years previously.

Sources: CleantechAlps, Cleantech Group

SWISS PORTAL FOR CLEANTECH START-UPS:

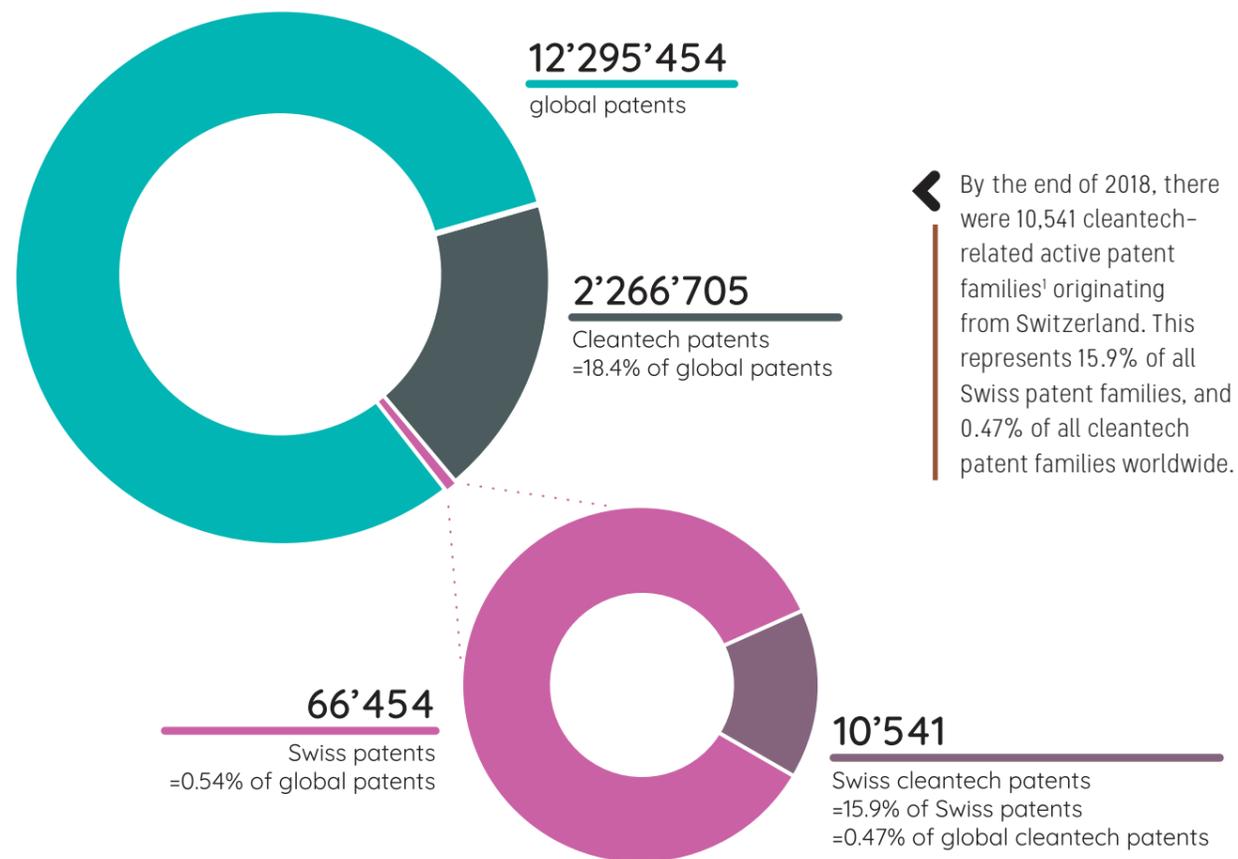
THE GO-TO DATABASE

Launched in 2017 by CleantechAlps, this portal brings together in one resource the country's cleantech start-ups. Every one of Switzerland's fledgling innovation and tech companies (which have a high growth potential) is listed on this website. The site's search functions - by keyword, sector and geographical location - give the nation's cleantech start-ups the visibility they need among the media, investors and industrial partners. This continually updated database is also a reliable source of information for generating statistics for the sector.

www.cleantech-alps.com/en/start-ups

IN COMPARISON WITH OTHER COUNTRIES, SWITZERLAND ACCOUNTS FOR ONLY A SMALL NUMBER OF CLEANTECH PATENTS, BUT SWISS INVENTIONS IN THIS FIELD ARE OF HIGH QUALITY. THIS IS THE OBSERVATION MADE BY THE SWISS FEDERAL INSTITUTE OF INTELLECTUAL PROPERTY.

The cleantech patent landscape from a Swiss perspective



¹ A patent family comprises all patents worldwide relating to the same common technological content and referring to the same original priority application. Active patent families are defined as patent families with at least one family member granted and in force, or pending at a given time point.

SWITZERLAND IS IN 14TH POSITION

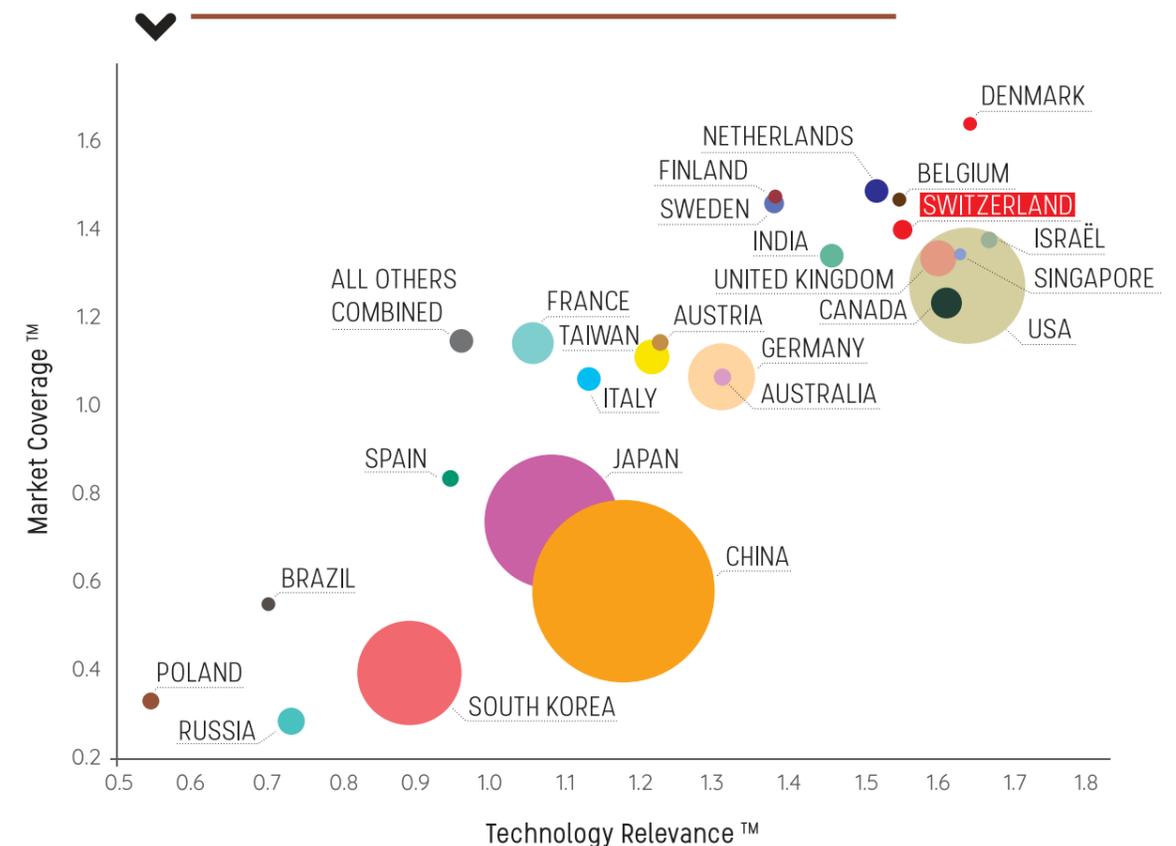
Worldwide, the number of active patent families has doubled between 2008 and 2018, from 6.5 to 13 million. This is mainly due to the large number of invention disclosures originating from China and South Korea. During the same period, the number of cleantech patents has increased from one to over two million active families.

On 31 December 2018, Switzerland ranked 14th among the countries of origin for active cleantech patent families. This is an outstanding result, given the size of the country relative to the quality of the patent portfolio. A full third (34%) of Swiss cleantech patents qualify as excellent patents, almost three times as many as the global average (13%).

These numbers reflect the innovation power of Switzerland, which relies on well-trained professionals, excellent infrastructures and framework conditions, and a strong international collaboration network. In addition, close support by IP professionals (patent attorneys, technology transfer offices) ensures that Swiss innovations are adequately protected by IP rights.

Cleantech patents by country of origin

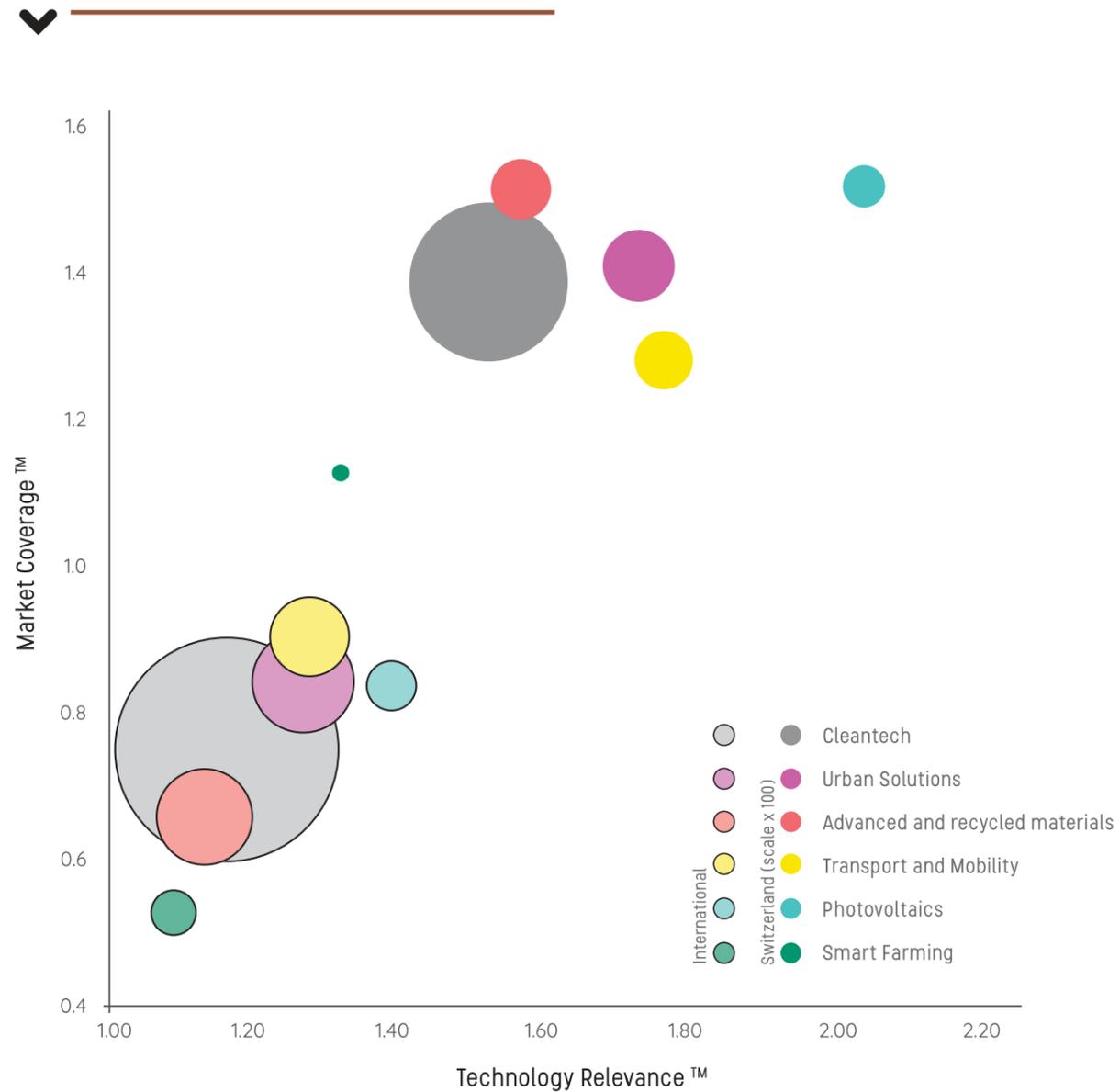
In terms of Technology Relevance™ and Market Coverage™, cleantech inventions of Swiss origin are among the best. Switzerland is ranked just below Denmark, along with a group of European countries that includes Belgium and the Netherlands.



SWISS INVENTIONS COMPARED TO GLOBAL AVERAGE

Selected cleantech sectors

International comparison shows that patents of Swiss origin are, on average, of higher technological quality and cover larger markets. This is true for all the sectors covered by this report. Photovoltaic technology alone accounts for 727 patent families of Swiss origin. The bubble sizes represent the relative numbers of active patent families. For better visibility, the Swiss bubbles have been enlarged by a factor of 100.



Technology Relevance™ and Market Coverage™ are qualitative parameters available in the patent analysis software PatentSight used for this report.

For more information: www.patentsight.com/patentsight-patent-asset-index

WHAT IS THE INSTITUTE OF INTELLECTUAL PROPERTY ?

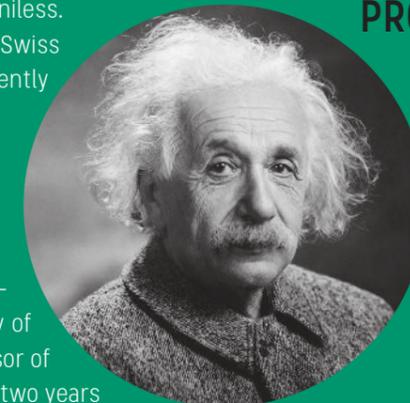
The Federal Institute of Intellectual Property (IPI) is Switzerland's centre of expertise in all matters concerning patents, trade marks, indications of geographic origin, designs and copyright. It is also responsible for preparing intellectual property legislation, advising the federal authorities and representing Switzerland at an international level.

The IPI examines, grants and administers industrial property rights. It protects the Swiss indication of origin within Switzerland and internationally, working with other authorities and with trade associations and businesses. It has a supervisory role in relation to collective rights management organisations. In addition, it provides information on intellectual property rights to individuals and companies in a variety of ways.

www.ige.ch

ALBERT EINSTEIN THE INTELLECTUAL PROPERTY INSTITUTE'S MOST FAMOUS EMPLOYEE

When Albert Einstein arrived in Bern in February 1902, he was penniless. He quickly found a job at the Swiss Patent Office, which subsequently became the Federal Institute of Intellectual Property (IPI). This job gave him the space he needed for his creative thinking to flourish. In 1907, he began lecturing in theoretical physics at the University of Bern, and he became professor of theoretical physics in Zurich two years later. He went on to become one of the most important physicists of his time.



Swiss cleantech innovation ecosystem

INTERNATIONAL ORGANIZATIONS

- > World Intellectual Property Organization (WIPO)
- > UN Environment Programme (UNEP)
- > United Nations Industrial Development Organization (UNIDO)
- > United Nations Framework Convention on Climate Change (UNFCCC)

FULL-SCALE TEST FACILITIES

- > Smart City Lab
- > GridLab
- > Smartlab
- > iHomeLab
- > Mobility Lab
- > Swiss Future Farm
- > Smart Living Lab
- > Swiss Innovation Lab
- > Bosch IoT Lab

ASSOCIATIONS

- > Swissolar
- > Suisse Eole
- > energie-cluster
- > Reffnet
- > swisscleantech
- > Organisation faîtière de l'économie des énergies renouvelables et de l'efficacité énergétique (AEE Suisse)
- > Schweizerischer Verband für Umwelttechnik (SVUT)
- > Swissmem
- > Swiss Water Partnership
- > Swiss Business Council for Sustainable Development (öbu)
- > Circular Economy Switzerland
- > CleantechAlps

INCUBATORS AND TECHNOLOGY PARKS

- > TecOrbe
- > BlueFactory
- > BlueArk Innovation Hub
- > Microcity
- > BlueBox
- > Energypolis & Alpole
- > Impact Hubs (ZH, BE, GE, VD, NE, ...)
- > TechnoParks (ZH, LU, AG, ...)

ACADEMIC INSTITUTIONS

- > Ecole polytechnique fédérale de Lausanne (EPFL)
- > Eidgenössische Technische Hochschule Zürich (ETHZ)
- > Adolphe Merkle Institute
- > Swiss Federal Laboratories for Materials Science and Technology (EMPA)
- > Paul Scherrer Institute (PSI)
- > Swiss Federal Institute of Aquatic Science and Technology (EAWAG)
- > Centre Suisse d'Electronique et de Microtechnique (CSEM)
- > Swiss Federal Institute for Forest, Snow and Landscape Research (WSL)

SWISS CONFEDERATION

- > Swiss Federal Office of Energy (SFOE)
- > Federal Office for the Environment (FOEN)
- > Swiss Agency for Development and Cooperation (SDC)
- > State Secretariat for Economic Affairs (SECO)
- > Innosuisse – Swiss Innovation Agency
- > State Secretariat for Education, Research and Innovation (SERI)
- > Federal Office of Transport (FOT)
- > Swiss Federal Institute of Intellectual Property (IPI)

INDUSTRY

- > SMEs
- > Start-ups
- > Corporates
- > Engineering practices
- > Utilities

EXTERNAL OFFICIAL NETWORK

- > Swissnex
- > Swiss Business Hubs
- > Switzerland Global Enterprise
- > Embassies & Consulates



“To be clean or not to be. Clean technologies are not just an innovative growth market for Switzerland. They are also an essential prerequisite for protecting our climate. Cleantech is the new normal!”

Regula Rytz

Member of the National Council and former President of the Green Party of Switzerland



“In a world of finite resources, we must change our model now and invest more in developing renewable energy sources if we are going to be able to celebrate EPFL's centenary in 2069.”

Martin Vetterli

EPFL President



“Switzerland has the ability to become a leader in clean technology and corporate responsibility. It is time to grab this opportunity by stepping up innovative partnerships.”

André Hoffmann

President of MAVA Foundation, Vice-Chairman of the Board of Directors of Roche Holding Ltd

Significant dates that have marked Switzerland's enduring love story with cleantech

Opening of the first Gotthard railway tunnel connecting the north and south of the country – and therefore of Europe – through the Alps.



1872

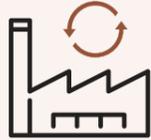


Commissioning of Europe's first concrete gravity dam, at Pérolles south of Fribourg.

Ernst Stadler founded Stadler Rail, a specialist train building company. Stadler Rail is one of the industry's world leaders, employing a workforce of more than 10,000 around the world. With ABB and Bombardier, both of which have a major presence in the country, Switzerland boasts considerable expertise in railway equipment manufacture.



1882



Opening of the KEZO waste processing plant near Zurich. This pioneering processing facility is today capable of separating waste and recovering from the slag 99% of materials such as gold, copper and aluminium.

The first multi-modal road-rail shipment was transported from Basel to Melide. This was the first instance of 'piggybacking' in Switzerland... and the world. Combining rail and road transport is a visionary solution that is safer, more reliable and more sustainable. Hupac was established in Ticino in 1968 by five pioneers: the transport companies Bertschi and Fratelli Bernasconi, the haulage contractors Danzas and Jacky Maeder, and Swiss Federal Railways (SBB).



1961



Opening of the Grande-Dixence, at 285 metres the tallest gravity dam in the world until today. This multiple-record-breaking dam was followed by a vast number of structures of all sizes throughout the country, showcasing Switzerland's prowess in hydroelectricity.

Founding of Nest, the first independent pension fund to implement an exclusively sustainable investment policy. At the end of 2018, this pioneer in sustainable finance was safeguarding the pensions of more than 3,300 companies.

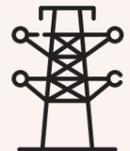


1962



The first PV installation in Europe was connected to the grid in Ticino. Mounted on the roof of the University of Applied Sciences and Arts of Southern Switzerland (SUPSI) in Lugano, it is still in operation today.

Launch of the '2000-Watt Society' model by the Swiss Federal Institute of Technology Zurich. Its aim is to achieve a continuous energy-usage requirement of no more than 2,000 watts per person per year – a visionary goal in terms of a political objective and one that is becoming a reality...



1964



Founding of ATG AutoTeilet Genossenschaft and ShareCom, resulting 1997 in the creation of the Mobility Carsharing cooperative, Europe's biggest car-sharing company, with 3,120 vehicles available from 1,480 stations around Switzerland.

1968

1982

1983

1987

1990

Significant dates that have marked Switzerland's enduring love story with cleantech (part 2)

The federal councillor Adolf Ogi presented Switzerland's first Energy City certification to the town of Schaffhausen. By the beginning of 2020, more than 430 of Switzerland's municipalities had achieved Energy City certification, which covers 60% of the Swiss population. This illustrates Switzerland's pragmatism and willingness to prioritise quality over quantity to develop a smart energy supply system and involve the country's citizens in the energy transition.



1990



Start of the PET recycling programme, which achieved a recycling rate of 83% in 2019.

1991

2009



The 'GeniLac' and 'Geneva-Lake-Nations' projects were launched. These innovative thermal solutions use water from Lake Geneva to cool and heat buildings in Geneva city centre.

The Federal Council announced its intention to phase out the use of nuclear power.



2011

2013



Commissioning of the Forsthaus energy plant in Bern. This was the first power plant in Switzerland to generate electricity and heat from wood, natural gas and refuse.

Opening of the new Gotthard Base Tunnel, at 60 km the longest railway tunnel in the world.



2016

2016



The world's first energy-self-sufficient residential complex was opened in Brütten (Canton of Zurich). The transformation of visionary ideas such as this into economically viable solutions is made possible by the extremely strong interconnections between the skills and expertise networks linking research institutes and SMEs.

Opening of the extension to the Linth-Limmern hydroelectric power plant (Canton of Glarus). This extension tripled the plant's power output to 1,480 GWh. The most spectacular part of this new facility is without doubt the wall of the Muttssee Dam, at 1,025 metres the longest in Switzerland.



2016

2017



On 21st of May the Swiss people voted in the revised Energy Act. Among other things, this act aims to reduce energy consumption, improve energy efficiency and promote the use of renewable energy sources.

SBB (Swiss Federal Railways - the national railway transport company) announced its plans to save 600 GWh of electric and fossil-fuel energy every year by 2025 (50% of this objective was reached in 2018).



2018

2019



On 20th of December, the nuclear power plant at Mühleberg was the first in Switzerland to be disconnected from the network.

Phasing in of the Nant de Drance power plant, the vast hydroelectric facility on the France-Switzerland border near Mont Blanc. The most recent of the large-scale installations of its kind, this will be one of the most powerful pumped-storage plants in Europe (900 MW and an average of 2,500 GWh generated every year). It illustrates Switzerland's willingness to develop this sector and exploit its water resources to the full.



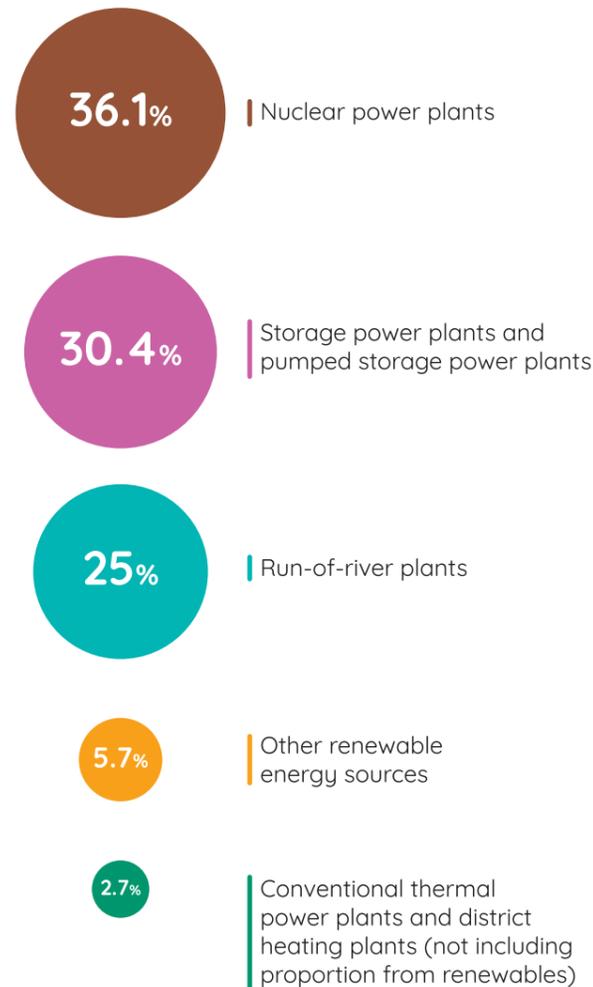
2020

IN 2018, THE COUNTRY'S GROSS ENERGY CONSUMPTION WAS APPROXIMATELY 1.1 MILLION TERAJOULES, OF WHICH ABOUT 85% WAS IMPORTED.

Switzerland's electricity generation and energy mix – close to zero-carbon

In terms of electricity consumption, hydroelectricity forms the mainstay of the energy supply. This energy mix generates extremely low quantities of CO₂ and helps to meet climate targets. On the other hand, phasing out nuclear energy will be a major challenge in the coming years and opens the door to the development of other renewable energy sources. According to the Swiss Federal Office of Energy (SFOE), Switzerland could generate up to 67 TWh of solar electricity a year from building roofs and façades, while the nation's electricity consumption is approximately 58 TWh.

On 25th of May 2011, the Swiss government (Federal Council) announced its intention to dispense with nuclear energy completely in the medium term. Following this sudden announcement made in the wake of the Fukushima nuclear disaster (2011), the Swiss people confirmed the decision in a referendum held in 2017, approving the strategy and a new energy act. Given that 36% of the country's energy mix was generated by nuclear power, it had become essential to ensure that the strategy was approved by the majority. This resulted in the 2050 Energy Strategy, which aims to reduce energy consumption, improve energy efficiency and promote the use of renewable energy sources. Switzerland's five nuclear power plants will be decommissioned at the end of their service life. On 20 December 2019, the Mühleberg nuclear power plant was the first one that disconnected.



SFOE, Global Swiss energy statistics, 2018

DETERMINED TO COMBAT GLOBAL WARMING TOO

In addition to securing a fossil-fuel-free energy supply, Switzerland is keen to combat global warming and reduce CO₂ emissions. The goal set by the government is for the country to reduce greenhouse gas emissions to net zero by 2050. This objective is the cornerstone of Switzerland's climate strategy in the wake of the Paris Agreement, under the framework of the UN Climate Convention. The idea is to use the latest technology and renewable energy sources to reduce CO₂ emissions from transport, building and industry by 95%. The remaining emissions will be compensated for by the use of natural carbon sinks (in forests and soils), greenhouse gas extraction and storage technology.

The 17 sustainable development goals (SDGs) featured in the United Nations' 2030 Agenda have also been approved in Switzerland. The country's 2050 strategy and agricultural practices already incorporate most of these objectives. Challenges remain however, such as introducing more sustainable consumption and production methods and reducing the negative effects of consumption habits.



SWITZERLAND MONOPOLISES THE TOP SPOT IN THE WORLD RANKINGS

Switzerland is often highly ranked in worldwide environmental indices and other comparison tables. Below is an overview of the most high-profile rankings:

2020 Environmental Performance Index:
3rd out of 180 countries (Yale University)



Global Innovation Index 2019 (GII):
1st out of 130 countries
For the ninth year running. (WIPO)

Global Cleantech Innovation Index 2017 (GCII):
10th out of 40 countries (Cleantech Group)

SUSTAINABLE FINANCE IS BOOMING

According to the latest available figures, there is growing demand for sustainable finance. Around 120,000 billion dollars' worth of financial assets, almost half of the world total, are managed by organisations that have signed the Principles for Responsible Investment (PRI), follow the recommendations of the Task Force on Climate-Related Financial Disclosures (TCFD), or both. As one of the world's principal financial marketplaces, Switzerland is an integral part of this trend.

According to the BCG's Global Wealth 2019 report, CHF 2.27 billion worth of international assets were managed in Switzerland at the end of 2018, positioning the country firmly among the leading wealth management centres of the world.

In the 1990s, Swiss financial institutions introduced discretionary mandates for sustainable investment. A major environmental accident caused by a pharmaceutical company led to the Bank J. Safra Sarasin launching the first dedicated mandates based on environmental criteria and the first environmentally focused mutual fund. Today, sustainability is systematically incorporated into the investment processes of a number of other Swiss banks.

The private bank Lombard Odier, a pioneer in sustainable investment funds, has been supporting the development of impact investing since the beginning of the 2000s, working with BlueOrchard to introduce this instrument before launching its own fund. Other institutions have been founded with the sole purpose of providing sustainable financial services, such as Banque Alternative Suisse in 1990, RobecoSAM in 1995, Forma Futura Invest in 2006 and Globalance Bank in 2011.

This dynamic situation gave rise to a new type of investment philosophy and vehicle besides crowdfunding, complementing the financial ecosystem with cooperatives aimed at creating a sustainable economy. ONE CREATION Cooperative (2010) is a Certified B Corp bringing a dedicated instrument to the investor community to support the rapid development of environmental technologies through a global multi-sector approach. This instrument is an innovative way of providing long-term financial support to those companies and helping them to achieve a wide range of the ecological, climatological and societal objectives that are part of a sustainable economy. It is also another way of supporting the long-term achievement of the COP21 and SDG objectives.

Over the years, several Swiss banks have also developed exclusive sustainability indicators for their investment portfolios.

According to Swiss Sustainable Finance, at the end of 2018 Switzerland totalled CHF 716 billion worth of sustainable investments, 21% of the total assets managed in Switzerland. This proportion is almost twice the world average for sustainable investments, which is estimated by McKinsey & Company to be 11%.



“We have been forging an unnatural world for nearly 250 years. We now have a chance to refurbish, reshape and continue building it, but this time with a view to creating a desirable future on the only bio-diverse planet in the solar system.

Olivier Ferrari

Sustainable entrepreneur and investor.
Founder and CEO CONINCO Explorers
in finance SA



“Every one of us — citizens, philanthropists, business and government leaders — should be troubled by the enormous gap between how little of our natural world is currently protected and how much should be protected. It is a gap that we must urgently narrow, before our human footprint consumes the earth's remaining wild places.

Hansjörg Wyss

Entrepreneur, businessman,
philanthropist, and founder of the Wyss
Foundation



© Sandra Hüser

“Both urgent and singularly complex, the ecological transition demands multidisciplinary responses, the pooling of strengths and an ongoing dialogue with the players on the ground.

Luciana Vaccaro

Rector of HES-SO University of Applied Sciences and Arts
Western Switzerland

“With a yield of 23%, the perovskite photovoltaic technology developed at EPFL Valais aims to produce light, high-power solar cells at a cost of less than 20 centimes per kilowatt: a revolution for the energy requirements of the future.

Mohammad Khaja Nazeeruddin

Professor at EPFL



© Sabine Papilloud-Le Nouveliste



“Swiss technologies are in a good position to contribute to a more sustainable world. Environmental and social responsibility should be at the heart of research and innovation, that is a must!

Christophe Ballif

Professor at EPFL and Director of the CSEM PV&Energy Center

“If we want to bring about the energy transition, we have to solve a key problem: how do we 'save' excess energy from the summer for the winter? One answer, which we are researching at Empa, is power-to-gas.

Gian-Luca Bona

CEO, Empa

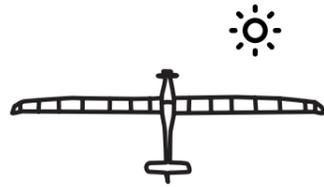


“The energy transition and climate change will be the main challenges in the 2020s: Swiss research, industry and start-ups are all contributing to local, national and global solutions.

Walter Steinmann

Senior Advisor at Credit Suisse Energy Infrastructure Partners

Swiss cleantech pioneers and records



SOLARSTRATOS : A SOLAR-POWERED STRATOSPHERIC AIRCRAFT

SolarStratos is an aeronautical mission to reach the stratosphere in a manned solar-powered aircraft for the first time. The brains behind this project is the adventurer Raphaël Domjan. The aim of this mission is to use an aircraft with a conventional electric motor to demonstrate the potential of solar energy.

www.solarstratos.com



SOLAR IMPULSE : THE FIRST CIRCUMNAVIGATION BY AN AIRCRAFT NOT POWERED BY OIL

A pioneering project involving a single-seater electric aircraft powered solely by solar energy, Solar Impulse features near-perpetual autonomous operation. The two pilots behind the project, Bertrand Piccard and André Borschberg, took turns at the controls to fly each stage, finishing in Abu Dhabi in July 2016 and completing the first solar-powered round-the-world trip by air, setting record after record along the way.

www.solarimpulse.com



“Tomorrow’s world will be a reflection of today’s wisdom.”

Raphaël Domjan

SolarStratos Initiator & Pilot

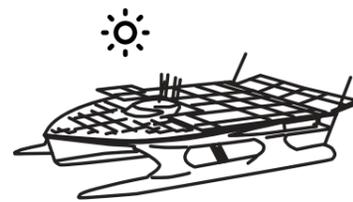
© Fondation PlanetSolar



“Conserving the environment should not only be something we strive to accomplish; it should be the way we live.”

Mike Horn

Extreme Adventurer



PLANETSOLAR : THE FIRST CIRCUMNAVIGATION BY A SOLAR-POWERED BOAT

The brainchild of Raphaël Domjan and equipped with more than 500 m² of solar panels, this is the largest solar-powered boat in the world. Between September 2010 and May 2012, the boat completed the first solar-powered round-the-world trip in history by any mode of transport, and it continues to ply the oceans today under the Race for Water banner. Race for Water supports various water-related projects, particularly an initiative to combat micropollutants. With this ambassador, Switzerland is more than ever a leading light in raising awareness of global environmental causes.

www.raceforwater.org



MONTE ROSA HUT : AN ALMOST SELF-SUFFICIENT MOUNTAIN HUT AT 3000 M ALTITUDE

This mountain hut owned by the Swiss Alpine Club, renovated in 2009, is at the cutting edge of sustainable development. Known as the ‘most complex timber construction in Switzerland’, this high-tech building with views of the Matterhorn at an altitude of nearly 3000 metres features an aluminium shell and a computerised energy management system which can be operated remotely.

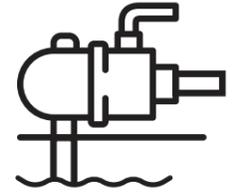
<https://monterosahuette.ch>



JOSEF JENNI : SWITZERLAND’S SOLAR ENERGY PIONEER

Josef Jenni is one of the pioneers of solar energy. His ‘Tour de Sol’, established back in 1985, was the first motor race for electric vehicles powered by photovoltaic energy instead of internal combustion engines. With his company Jenni Energietechnik AG, he also established the first building in Europe to be heated entirely by solar energy and the first detached family home to have all its energy needs supplied by solar power.

www.jenni.ch



HEAT PUMPS : SWITZERLAND LEADS THE WAY

Switzerland is in pole position with the highest number of geothermal probes and heat pumps in the world, at an average density of one installation every 2 km² (source: SIG). The Swiss Federal Office of Energy considers heat pumps to have great potential: in 2020, the number of heat pumps in Switzerland is set to reach 400,000 units.

www.suisseenergie.ch

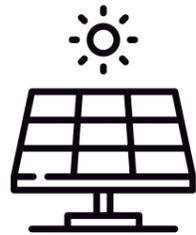


A RECYCLING RATE SECOND TO NONE

Switzerland is the world leader in recycling and waste reprocessing. The country’s considerable expertise in the art of recycling includes glass, aluminium cans, PET bottles, organic waste and electrical and electronic equipment.

www.swissrecycling.ch

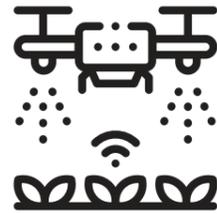
Swiss cleantech pioneers and records



LARGER PV SOLAR POWER SYSTEM

Thirty-one thousand solar panels covering an area of 50,500 m², the equivalent of seven football pitches: that is the size of Switzerland's largest photovoltaic plant. The panels are mounted on the roof of the former Philip Morris warehouses in Onnens (Canton of Vaud) and have an installed capacity of 8.3 MW.

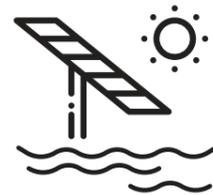
www.soleol.ch



A EUROPEAN FIRST : CROP SPRAYING BY DRONE

In 2019, with the collaboration of AgroFly, Switzerland became the first European country to develop a procedure for authorising crop spraying by drone. It is now possible to obtain a licence for crop spraying by drone as an alternative to the use of helicopters.

www.foca.admin.ch



A WORLD FIRST : A FLOATING SOLAR FARM

In December 2019, energy distributor Romande Energie opened the first alpine floating solar farm. Six years of development work and more than 10 months of construction work were required to develop the first ever installation of its kind in an alpine environment. Built on the Lac des Toules (in the Grand Saint Bernard – Canton of Valais), at an altitude of 1810 metres, this solar farm will produce more than 800,000 kWh a year, as a pilot scheme designed to test the technical and financial feasibility of a larger project.

www.romande-energie.ch



“A relationship with planet Earth based exclusively on using it for economic growth is only ever going to result in damaging the Earth and impairing human life.”

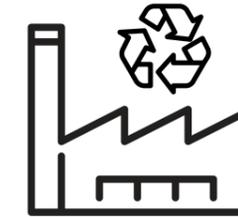
Claude Nicollier
Swiss astronaut



THE RETURN OF THE HYDROGEN BALLOON

In October 2019, the Swiss team of Laurent Sciboz and Nicolas Tièche won the Gordon Bennett Cup, travelling 1,774 kilometres in just under 83 hours in a balloon filled only with hydrogen. The team is now planning to fly for even longer by building a larger balloon, one the size of the Victoria, the balloon featured in the Jules Verne novel Five Weeks in a Balloon.

www.frchallenge.ch



DRIVING THE CIRCULAR ECONOMY OF A WHOLE REGION

SATOM SA in Monthey (Canton of Valais) is the waste-to-energy recycling plant that generates the most electricity in Switzerland. The plant's incinerators generate enough energy to power the equivalent of 40,000 homes. It is a shining example, the driving force behind the development of a whole region, pioneering in terms of waste usage in the circular economy and at the cutting edge of global energy management at regional level.

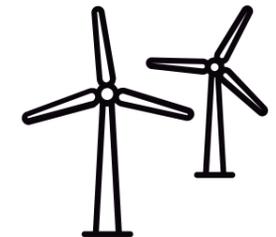
www.satomsa.ch



HYDROGEN-POWERED TRUCKS

In 2019, the motor manufacturer Hyundai and the Swiss company H2 Energy began production of the first fleet of trucks powered by hydrogen. The objective is to supply 1,600 trucks for the Swiss market by 2025.

www.h2energy.ch



GRIES WIND, EUROPE'S HIGHEST WIND FARM

The highest wind farm in Europe, located near the Nufenen Pass in southern Switzerland at an altitude of around 2500 metres, has been generating electricity since 2011. Three new turbines began operating there in 2016. The four turbines on the site generate approximately 10 GWh of electricity per year.

<https://gemeinde.obergoms.ch/energie/>



READ ON TO LEARN MORE ABOUT SWITZERLAND'S CLEANTECH CREDENTIALS. ADDITIONAL CONTENT IS AVAILABLE THROUGH THE SWISS CLEANTECH REPORT WEBSITE

www.swisscleantechreport.ch



The overview presented in the previous pages highlights Switzerland's drive, commitment and outstanding performance in a vast number of cleantech-related fields. This is the result of the country's diverse economic fabric and close collaboration with research institutes of international standing.

In the following pages, we look in more detail at the five main fields in which Switzerland is particularly innovative, developing export-ready solutions and technologies that can make a contribution to our joint efforts to address the climate change challenges we all face. Each topic covers the state of play and where Switzerland scores highly, along with a focus on the mature technologies and a sample of up-and-coming companies that have come into being through Switzerland's innovation-packed ideas pipeline.



“We need to embrace clean technologies and efficient solutions, because they are much more than “ecological”, they are “logical”. They create jobs and generate profit, while also reducing CO₂ emissions and preserving natural resources. Even if climate change didn't exist, they would make sense. Clean growth is much better than the dirty status quo we have today.

Bertrand Piccard

Initiator, Chairman and Solar Impulse Pilot



“Reducing our CO₂ emissions is dependent on our attitude and willingness to change. We need to act now to choose the most efficient technological solutions.

André Borschberg

Co-Founder of H55 and Solar Impulse Pilot



SMART FARMING & DRONES

Smart farming & drones

In Switzerland, as elsewhere, market globalisation and the opening-up of trade are placing agriculture under pressure. Population growth and increasing urbanisation are leading to a reduction in farmland and biodiversity. Switzerland therefore needs to exploit every opportunity for optimisation or improvement in order to protect its agricultural and environmental conditions and provide food security.

Smart Farming is one solution to this major challenge. Agritech should increase agricultural competitiveness, for example by providing farmers with decision support tools. Furthermore, the Federal Council's Digital Switzerland strategy places a special emphasis on smart farming, in conjunction with artificial intelligence (AI), as a means of boosting both competitiveness and sustainable development in the agricultural sector.

SMART FARMING HAS BEEN ON THE SCENE IN SWITZERLAND FOR A FEW YEARS, THANKS TO THE EFFORTS OF RESEARCH ORGANISATIONS, STARTUPS AND SMES OPERATING IN THIS FIELD. IT HAS EIGHT PRACTICAL OBJECTIVES:



INCREASING PROFITABILITY, BY REDUCING COSTS AND INCREASING EFFICIENCY, WHILE ALSO RELIEVING WORKERS OF ROUTINE TASKS

IMPROVING QUALITY, FOR EXAMPLE BY REDUCING THE USE OF ANTIBIOTICS AND PESTICIDES



MINIMISING EMISSIONS, TO PROTECT WATER SOURCES IN PARTICULAR

BETTER PROTECTION OF RESOURCES (WATER, SOIL, AIR, ETC.)



SELF-SUFFICIENCY IN ENERGY

AN OVERALL IMPROVEMENT IN THE HEALTH AND WELL-BEING OF LIVESTOCK



REDUCING EMISSIONS OF CO₂ AND NOISE, BY USING ELECTRICALLY-POWERED EQUIPMENT

REDUCING SOIL COMPACTION, USING DRONES OR ROBOTS INSTEAD OF HEAVY TRACTORS AND MACHINES



New technology affects all aspects of agricultural production: the management of soil, water, crops and herds, plant protection, animal health and mechanisation, to name but a few.

Consequently, precision agriculture is gaining popularity, in Switzerland as in other countries. The combined use of Information Technologies (IT), electronic and mechanical aids to improve agricultural efficiency enables farmers to stabilise yields and reduce harmful effects on the environment, particularly those caused by the misuse of pesticides.

Agriculture is also coming under ever-greater pressure from the public, who want its impact on the environment to be reduced. As robots and drones are able to perform field operations in a more time- and space-efficient manner, they will play an important role in the near future.



However, the future of agriculture does not rely solely on the development of more efficient machines and robots. Smart sensor systems, which generate the data needed for precise monitoring, will also play an increasing part, as will data interpretation and parameter optimisation. By incorporating the use of these new technologies farmers will have additional possibilities to able to complement their existing practices, while also taking wildlife into consideration.

The Swiss Future Farm (SFF) was formally opened at Tänikon in September 2018. This centre of excellence for agricultural research, coordinated by Agroscope in conjunction with various partners, including universities and private companies, offers the only experimental platform in Europe that focuses on IT in agriculture

AGRICULTURE AND CLIMATE CHANGE

Looking beyond smart farming, climate change presents a major challenge to agriculture. The sector must make an effective contribution to climate protection by drastically reducing its greenhouse gas emissions. At the same time, it must adapt its production by anticipating climate change and mitigate the negative effects on crop yields and the environment.

Agriculture is therefore both a victim of and a trigger in climate change. On the one hand, this sector directly influences the amount of greenhouse gases present in the atmosphere by emitting these gases or by capturing carbon in the ground. On the other hand, climate change influences the conditions for agricultural production, for example when there is too much or too little rain.

With this in mind, the Swiss Confederation has established a climate strategy for agriculture, which aims to increase production while reducing greenhouse gas emissions. The objective is to reduce emissions from agriculture by at least a third by 2050, and even two-thirds for the entire agrifood sector. This target is ambitious, but realistic in the long term. One of the solutions for achieving it is a cattle food additive sold by Agolin. This natural additive reduces emissions of methane into the air by improving the digestion and well-being of cattle (see page 50).

The challenge presented by climate change requires some agricultural practices and methods to be adapted, but changes are also required in industry, retailing and consumer behaviour. A high degree of commitment is therefore needed from all the actors involved in agriculture and the food industry.



51,620
number of farms
in Switzerland in 2017

14'817 km²
agricultural area in
Switzerland (35,9% of
the total surface)

130 kilos
weight of the ecoRobotix
autonomous weeding robot

81 hectares
cultivated area of the Swiss
Future Farm, which is
devoted to smart farming
experiments



33% Target reduction in CO₂ emissions
from Swiss agriculture by 2050

66% Target reduction in CO₂ emissions
from the agrifood sector by 2050

13% of the total:
current CO₂ emissions from
the agriculture sector in
Switzerland¹

¹ Agricultural report, Federal Office for Agriculture

Swiss solutions for the agriculture of the future

FOR SEVERAL YEARS, SWITZERLAND HAS BEEN DEVELOPING PRACTICAL SOLUTIONS TO MEET THE CHALLENGES TO AGRICULTURE. THESE INCLUDE EMERGING TECHNOLOGIES SUCH AS DRONES.

DRONES

At the moment, drones are used in agriculture mainly for monitoring and product application. They provide useful data and pictures from hard-to-access sites, and will probably soon be essential in consultancy and agricultural mapping activities. These applications include, for example, the protection of young deer through the use of drones with infrared cameras when meadows are mowed in spring.

Switzerland was the first country in Europe to develop an authorisation procedure for crop-spraying by drone. Using various studies, five federal bodies jointly defined this procedure within two years, illustrating the drive and determination of public actors to support sustainable solutions. The objective is to make the possibilities offered by drone technology accessible in practice, in particular as a low-drift alternative to crop-spraying by helicopter. Such initiatives help to place Switzerland among the European leaders in applying drone technology.



© Patrick Huerlimann - Keystone

Drones are used to apply various kinds of crop protection products. One successful example of this is the release of capsules containing *Trichogramma*, a parasitic wasp used as a biological control to combat corn borers and other insect pests. The spraying of liquid pesticides, on the other hand, is subject to stricter legal limits and is far more difficult to implement. It is still in a development phase, at both a technical and legal level. However, Switzerland is at the forefront internationally in the development of drone applications in vine-growing, especially on steep ground. This technology is set to gain ground in other areas such as market gardening, and precisely-targeted preventative operations for large-scale crops. Young companies such as Aero41 (Aigle, Canton of Vaud), Agri.Aero (Sierre, Canton of Valais) and AgroFly (Monthey, Canton of Valais) are already actively involved in this field.

Switzerland's Drone Valley enterprises make it a world leader in the development of drone technology. At the moment, the focus is mainly on sensors, air traffic data systems and data processing. Although drones are not widely used in Swiss agriculture at present, they have tremendous potential for the future of the sector. Startups such as senseFly (Cheseaux-sur-Lausanne, Canton of Vaud) and Wingtra (Zurich, Canton of Zurich) are constantly developing new drone applications.

ROBOTS

The automation of agriculture is already under way, even in a small country like Switzerland, as demonstrated by the rapid growth of ecoRobotix (Yverdon-les-Bains, Canton of Vaud). This company is developing an autonomous robot, powered by integral solar panels, that can weed whole fields with tremendous accuracy.

Another company, Gamaya (Morges, Canton of Vaud), is developing high-tech cameras that enable farmers to analyse the state of their crops and the treatments required. Detailed images – to the nearest pixel – give valuable information about the physiological condition of the plants, information that can then be used by autonomous agricultural machinery.

In addition to farms based on aquaponics or mobile aeroponic systems like that used at CombaGroup (Molondin, Canton of Vaud - see page 49), there is also a trend towards automated vertical farms. Ecogrow (Bussigny, Canton of Vaud) has established its vertical farm near Lausanne, with the aim of recreating an ecosystem in a closed environment, without applying fertiliser, and minimising its energy consumption through the use of LED lighting. Another such farm was established near Basel by the startup Growcer (Basel, Canton of Basel-City) at the beginning of 2020. Machines manage the sowing, watering and harvesting of the crops, which are delivered to a nearby supermarket. This farm can grow crops throughout the year, without soil or pesticides and using 90% less water than standard agricultural systems. Space is optimised too: a floor area of 400m² provides a growing area of some 1000m².

One further example is QualySense (Opfikon, Canton of Zurich), which offers an automated system that sorts grain and seed efficiently in accordance with criteria defined by the farmer. This system can inspect around 30 grains per second.

These are just a few examples of the integration of robots into Swiss agriculture.



© Combagroup



ETH Zurich develops innovative digital technologies to support sustainable agriculture.

© 2020 ETH Zürich



© FELCO

DIGITAL APPLICATIONS

The 2018 Charter on the Digitalisation of Swiss Agriculture and Food Production, an initiative of the Federal Council, created a partnership between its signatories. These partners undertook to contribute actively to the automation of agriculture and the agrifood sector in Switzerland. As a result, an increasing number of digital applications are being produced so that agricultural data can be fully exploited. One instance of this is AgriCircle (Rapperswil, Canton of St-Gallen), a digital platform that helps to increase productivity and sustainability. Another is the computerised farm solution developed by Barto (Bern, Canton of Bern), which simplifies management, planning and reporting tasks for farmers.

The FarmX platform (Courtételle, Canton of Jura) uses a smartphone app to facilitate networking among farmers and the sharing of agricultural machinery that is often very expensive. Agridea offers a broad range of software packages adapted to the requirements of all the different sectors within Swiss agriculture and all farming systems.

The pruning equipment specialist Felco (Val-de-Ruz, Canton of Neuchâtel) has also invested in IT. With the help of the University of Applied Sciences and Arts Western Switzerland (HES-SO), it has developed a complete geolocalized IT solution to optimise vineyard management. This decision platform makes it easy to spot vines that are diseased, and to schedule the tasks of vineyard workers.

OTHER INITIATIVES

Agriculture is also moving into the very heart of towns and cities, through initiatives like that of CitizenBees (Neuchâtel, Canton of Neuchâtel) and its beehives. This company is developing an urban beekeeping service that enables commercial and local government organisations to host beehives on the roofs of their premises, so they can play a part in protecting bees. Vatorex (Wiesendangen, Canton of Zurich) provides a natural method of combating the varroa parasite, which threatens the survival of bees. The company has also developed a mobile phone app that simplifies the organisational and administrative work related to beekeeping. Switzerland is definitely a hive of activity in agricultural innovation!

To be mentioned in the agrivoltaics, Allani Sunlife Holding (Fribourg, Canton of Fribourg) with its expertise in the development of solar dryers, ideal for bio production on the north African market, so as Insolight (Lausanne, Canton of Vaud) developing a high-efficiency translucent module for this market.

INNOVATION PIPELINE

A host of Swiss companies and institutions are currently working on innovations. Here, we focus on a few new products and services with huge potential that are coming onto the market...



© Ecorobotix

ECOROBOTIX

The development by ecoRobotix of the first fully autonomous weeding machine makes weeding operations more environmentally friendly and economical. This wheeled robot is powered by photovoltaic panels, and can treat up to 10 hectares per day. Its built-in algorithms enable it to make accurate, targeted applications of weedkiller. The net result is a 90% reduction in the amount of weedkiller used and a significant reduction in costs and environmental impact.

www.ecorobotix.com



© Alain Herzog, EPFL

GAMAYA

Gamaya is developing an aerial imaging system that provides information on soil condition and composition. Using a small hyperspectral camera integrated into a drone, its technology provides large-scale crop diagnostics, particularly in relation to pests, diseases and weeds.

www.gamaya.com



© AgroFly

AGROFLY

AgroFly is developing a crop-spraying drone that is of particular use to vine-growers. The company aims to shape the environmentally responsible agriculture of the future, by applying the right products at the right time and in the right place. This technique reduces soil compaction and provides treatments that are more accurate and use smaller quantities of pesticides.

www.agrofly.aero



© Wingtra

WINGTRA

The drones developed by Wingtra are fitted with multi-spectral cameras and sensors. They can therefore identify and quantify crop health problems, with an accuracy of one centimetre, at a very early stage.

www.wingtra.com

XFARM

xFarm is a platform created by farmers for farmers that makes it easier for them to engage with the world of digital agriculture. It simplifies data collection and analysis, reduces paperwork and makes agricultural products traceable. The platform is based on management software, in conjunction with in-field sensors. It also has modules for financial management, crop and fertilisation scheduling, agricultural product traceability, disease alerts, irrigation advice and farming weather forecasts.

www.xfarm.ch



© xFarm

ALVER

Alver is a startup that sells innovative food products, including Golden Chlorella. This neutral-tasting algae powder contains 63% protein, making it the leader in its class. Production of this superfood requires just 2% of the arable land and 2.5% of the water required to produce traditional animal proteins. It can be added to fruit juices, sauces or vegetarian dishes.

www.alver.ch



© Alver

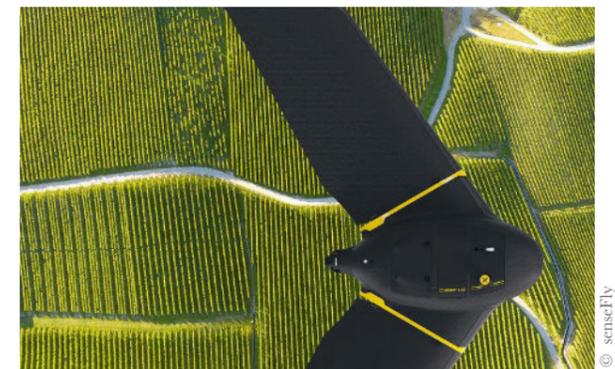


© PME Magazine

AGROSUSTAIN

AgroSustain offers a defence in the battle against moulds. It develops and markets natural solutions to halt and prevent the development of moulds on crops post-harvest. These products use plant-derived antifungal compounds and are applied to fruit and vegetables in sorting or packing facilities to extend their shelf-life.

www.agrosustain.ch



© senseFly

SENSEFLY

senseFly offers drone-based crop monitoring. The drones obtain high-definition images that are used by specialist software to produce models of the soils under cultivation (temperature, humidity, gradient, etc.). They not only make it possible to monitor plant growth and anticipate any problems, but also to predict yields, evaluate treatments or plan the drainage operations required for the next season.

www.sensefly.com

Using drones to up the eco-ante for organic wines



There are plenty of good reasons for using drones to spray crops: they are ultra-accurate, quiet, fast and effective. Arguments that have already convinced Swiss winegrowers and are set to win over producers outside Switzerland too.

Aero41 specialises in crop spraying by drone, working with a network of partners to develop and manufacture sprays and provide spraying services to farmers and winegrowers. Before founding the company in 2019, Frédéric Hemmeler flew helicopters for 15 years. So when it comes to aerial crop spraying, he knows his onions. He also knows that, sooner or later, Switzerland will have to fall into line with its European neighbours, which banned aerial spraying years ago.

That is what got him thinking about using drones to replace aircraft, an idea that has plenty going for it. “They are quieter and also extremely accurate. There is practically no spray drift, which has always been the main problem with conventional aerial spraying. We are getting results comparable to ground treatments – and our customers confirm that. There is almost zero waste because we’re pretty much able to control the direction of every droplet,” claims Frédéric Hemmeler. What’s more, Aero41’s drones are licensed as a ground treatment because they don’t need to fly high to be effective. By minimising its flying altitude, the drone is able to use the downward air currents generated by its propellers to disturb the leaves, ensuring a more even distribution of the sprayed product. This feature is of particular interest to organic producers because plant coverage must be optimised for the product to be effective. Aero41 is currently working on upgrading its drones to meet customers’ needs

even more effectively in the future. Using artificial intelligence (AI) and geolocation data in particular, the drones are even capable of recognising a particular field, which further increases their accuracy and effectiveness.

A potential for 100,000 hectares in Europe alone

Winegrowers using difficult-to-access land quickly realised the advantages of this product and were the first to adopt the technology. And that’s fine with Frédéric Hemmeler: in Europe alone, the primary market targeted by his company, he has identified around 100,000 hectares of vines cultivated on gradients of more than 30%. On this type of terrain, it is estimated that spraying one hectare requires four hours of manual labour. A drone can do it in 60 to 90 minutes. Not only that, it prevents the soil erosion caused by a tracked spraying vehicle. And last – but by no means least – drone spraying avoids any human contact with the produce. A way of enabling the drone to refill autonomously is also on the drawing board.

Switzerland and Austria have already licensed the use of drones, and certification is pending in France, Germany and Italy. Wine producers on the West Coast of the USA have shown an interest too.

Aero41
www.aero41.ch

CombaGroup grows cleaner vegetables



Growing high-quality lettuces, herbs and vegetables locally while saving water and preserving resources: this is the boast of CombaGroup, based at the Molondin Agropôle north of Lausanne.

Using conventional farming methods, one kilo of lettuce requires 250 litres of water to grow to maturity. Grown on CombaGroup’s mobile aeroponics platforms, it needs just seven. What’s more, 10 to 12 harvest cycles can be grown per year in the facility, compared to just one or two out in the field. And without leaching the soil, because there is no soil. The plants are grown in a greenhouse of course, but making maximum use of daylight.

This is no miracle, but a feat of technology: the gardening is done by robots, which are programmed to spray a very precise quantity of nutrient solution onto the plant roots to ensure they grow at the most efficient rate; the dosage depends on the plants’ maturity. “The quantity of nutrients, the height and strength of the mist, and even the water droplet shape: everything is carefully fine-tuned,” says Serge Gander, CEO of CombaGroup. Even the crops themselves are mechanised, because the plants are automatically shunted along as they grow. On each line, the robots are programmed to treat the plants, dosing the nutrient spray with an incredibly high accuracy.

Better conservation and less waste

Closed-circuit fogging also prevents any runoff into the soil. “We can do without it, unlike systems that operate with stagnant water, which is the perfect breeding ground for bacteria like salmonella.” In addition, working in this highly controlled environment means the company can

produce foods of consistent quality and quantity all year round. And because it grows locally, close to its consumers, CombaGroup provides a solution with a small ecological footprint. Its customers include restaurants and catering businesses, agrifood and pharmaceutical companies and even cosmetics manufacturers. Avoiding long-distance lorry transport also increases the products’ lifespan and reduces production losses to 10%, compared to more than 60% using conventional methods.

Established in 2013, CombaGroup is a promising scaleup company that employs a workforce of around 15. It now exports to France, where it has won a contract with a distributor of ready-to-eat crudités, and its products will be in the fridge of homes in French-speaking Switzerland from the end of 2020. Discussions with prospective customers are currently under way in the UK, Sweden, Russia and the Middle East, countries which lack the sunlight, warmer temperatures or fresh water for successful market gardening. Highly productive – 80 kg per square metre compared to three under conventional methods – this system may also help meet increasing demands on food supply.

CombaGroup
www.combagroup.com

Agolin reduces the CO₂ impact of cattle farming



The company Agolin (in Bière, Canton of Vaud) markets a plant-based feed additive that helps reduce methane emissions from cattle, providing an effective low-cost solution to limiting the production of greenhouse gases in the farming industry.

According to the United Nations Food and Agriculture Organization, dairy cows and beef cattle produce nearly five billion tonnes CO₂ equivalent every year worldwide, accounting for around 10% of all emissions generated by human activities. 40% of these emissions are generated by the animals belching during the digestion process.

The feed additive developed by Agolin contains plant extracts and is available in both a standard version and in an organic version that complies with organic farming regulations. The additive, called Agolin Ruminant, was originally developed to improve cows' digestive function with a view to increasing milk production – or weight gain in the case of meat herds. This is because more efficient digestion gives the cows a 4% better energy yield from their feed on average. “The reduction in the amount of methane produced is a side effect,” says Kurt Schaller, co-founder and director of the company. A very useful property when it comes to limiting greenhouse gas emissions from ruminants, which are estimated to be 0.5 m³ per animal per day.

Scientific rigour

One gram of the additive mixed daily into the feed given to each cow reduces its methane production by 10 to 20%. These figures have been measured and confirmed in a number of trials, many of which were part of research projects in which Agolin has been involved. Because at

Agolin, scientific rigour is of vital importance. “We are the first and only company to have carried out long-term academic trials on herds of 150 cows measuring performance, animal wellbeing and gas production,” says Kurt Schaller.

The company exports 99% of its production, mainly to Europe, with the greatest market penetration so far being in Norway, where more than 50% of the cows are fed with Agolin. “The Scandinavians are particularly sensitive to the climate protection argument,” he says. Using this additive could reduce the methane impact of cattle by 200'000 tonnes CO₂ equivalent per year in Europe, based on current cattle numbers. The potential for methane emissions reduction worldwide is huge: 200 million tonnes CO₂ equivalent, four times the total impact of Switzerland's farming industry. And the cost involved is relatively modest, being estimated at 25 euros per tonne of methane saved. The feed additive was awarded Carbon Trust certification in 2018 in recognition of Agolin's efforts in combatting climate change. “Honesty is a value that we hold very dear; we don't make any claims that can't be quantified and proved scientifically,” concludes Kurt Schaller.

Agolin
www.agolin.ch



© Agroscope, Gabriela Brändle



“The cleantech sector is of major importance to Switzerland's innovation potential. The Swiss Confederation therefore attaches great importance to the training of specialists with advanced skills in the field.

Martina Hirayama

Secretary of State for Education, Research and Innovation (SERI)



ADVANCED & RECYCLED MATERIALS

Advanced & recycled materials

As a prosperous country, Switzerland consumes more resources than the worldwide average and is unsurprisingly one of the biggest producers of municipal waste. To minimise the environmental impact of this, Switzerland has a responsibility to be inventive. The processing and recycling requirements and potential of this waste are high, and Swiss companies boast a range of technologies in this field. The country has developed particular expertise in the different recycling sectors, some of which serve as an example to other countries.

Taking recycling one step further, companies and research institutes are working on new materials with new properties which make them easier to recycle or lessen their impact on the environment. Underlying this industry, but with a much broader scope, there is the less visible circular economy waiting in the wings to play its part.

According to the European Environment Agency (EEA), Switzerland is actually leading the way when it comes to resource productivity. This classification measures economic output per unit of processed material. Switzerland is ahead of the Netherlands, the United Kingdom, Luxembourg and Italy¹. This classification provides an indication not only of how efficient a country's economy is at using resources but also how it is influenced by the types of material resources available locally. Countries with service-based economies like Switzerland will tend to have higher resource productivity than economies with a high proportion of heavy industry, since service industries typically have a lower demand for resources and materials.

¹ Full classification and details available at www.eea.europa.eu/airs/2018/resource-efficiency-and-low-carbon-economy/resource-efficiency

In Switzerland, putting waste in landfill has been prohibited since January 2000, except in certain strictly regulated individual cases. This legal provision has a major influence on the construction and civil engineering industry, which is forced to find innovative, environmentally friendly solutions for disposing of its waste. To meet this demand, Switzerland has developed various innovative building-design solutions like the concrete slabs manufactured by Cobiach (Schaffhausen, Canton of Schaffhausen). These slabs use less concrete while retaining their static properties. In early 2020, Holcim (Rapperswil, Canton of St Gallen) launched a new cement that makes better use of resources by re-using unsorted aggregates reclaimed from demolition projects, and Terrabloc (Geneva, Canton of Geneva) supplies unfired bricks made with materials excavated on site. In addition, SELFRAG (Kerzers, Canton of Fribourg – see page 64) has developed a material defragmentation solution. Designed originally to break up civil engineering waste, this technology has found a second application in processing the residue from incineration plants, particularly ferrous materials.

On the subject of incineration residue, the Zurich-based company Hitachi Zosen Innova (Zurich, Canton of Zurich, established in 1933), which specialises in constructing processing plants, has extended its range of expertise along the value chain by developing recycling technologies for slag generated from glass, minerals and scrap metal. This technology, like Selfrag’s solution, ties in completely with the concept of urban mining, which uses recycling, mainly of household appliances, to create a new source of raw materials. These raw material recovery concepts are applied in some processing plants such as the KEZO plant in Hinwil (Canton of Zurich), operated by ZAVRecycling, which has developed a dry slag processing technique.

Switzerland also has processing plants specialising in electronic waste for things like printer cartridges (Immark in Regensdorf, Canton of Zurich) and batteries (Batrec in Wimmis, Canton of Bern).

In Switzerland, some four million tonnes of waste are incinerated in waste processing plants every year. This recycling generates around 80,000 tonnes of fly ash, which contains volatile metals such as zinc, lead, copper and cadmium. From 2021, all of this fly ash will have to be recycled. SwissZinc (Bern, Canton of Bern) is set to provide a centralised recycling facility for the residual sludge recovered after the fly ash is recycled. This new plant, planned for 2025, will recover metals that can be reintroduced into manufacturing cycles.



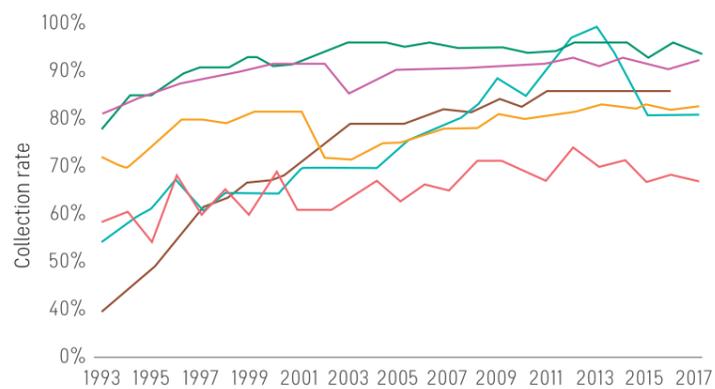
MUNICIPAL WASTE

In 2017, Switzerland was home to 30 MSWIs (municipal solid waste incinerators), with a capacity of between 30,000 and 230,000 tonnes each per year. The total amount of combustible waste from Switzerland and abroad processed in these MSWIs was around four million tonnes.

The figure below shows the extent of the waste sorting and collection culture in Switzerland, with the change in the recycling rate for glass, PET, aluminium cans, paper and cardboard, tin, and batteries.

Waste management is probably the sector that best illustrates the paradigm shift that is required to ensure better protection of the environment in the first instance, but more importantly to work ultimately towards a more sustainable society. This entails better use of resources in the first place and then ensuring their more effective re-use, because if energy efficiency is the fuel of the future, sorting and recycling are new sources of raw materials!

Switzerland's waste management system is an integrated model that has evolved over the years. The changes it has seen have been dictated by a regulatory framework made up of successive laws and regulations passed at federal, cantonal and municipal level over more than 30 years. In response to this complex legal framework, an infrastructure has grown up that is organised and connected at every administrative level.



© Source: Swiss Federal Office for Environment, 2019



© Vetropack

© Fédération des coopératives Migros

THE EXAMPLE OF PET RECYCLING

PET bottle recycling began in Switzerland in the early 1990s. By 1993, the recycling rate was already 60%, and by 2018 it had reached 82%². This was due mainly to the discipline of the Swiss population and information campaigns, but also to the considerable increase in the number of collection points around the country. Two-thirds of the material collected has been re-used in Switzerland and abroad to manufacture new bottles.

Thanks to the efforts of Cand-Landi (Grandson, Canton of Vaud) and its subsidiary RC-Plast, a complete PET collection and compacting recycling chain has become established. The PET is then recycled and processed into new packaging by the Resilux group, before being re-injected into the economy. The drinks producer Aproz (Aproz, Canton of Valais) also now packages part of its fruit cordials range in 100% recycled PET bottles. Similarly, Valser mineral water (Vals, Canton of Graubünden) is sold in bottles made of 100% recycled PET.

But Switzerland is not content to rest on its laurels – it is still striving to go further. Like the start-up DePoly (Sion, Canton of Valais), which has developed a more environmentally friendly way of recycling PET by breaking it down into its basic constituents and UHCS (Sion, Canton of Valais), which uses recycled PET in construction (see page 60).

When it comes to plastics in general, increasing numbers of smart recycling initiatives are being developed. The start-up Tide Ocean (Basel, Canton of Basel-City), for example, recycles all sorts of plastics including plastics recovered from the oceans, turning them into bags, carpets and even shoelaces.

² petrecycling.ch

FOOD WASTE

Food that is thrown away when still edible represents a considerable burden on the environment. This wastage is responsible for 25% of the Swiss food industry's environmental impact³.

As part of its Sustainable Development Goals (SDGs), Switzerland has committed to halving the amount of food waste per inhabitant by 2030, at both the distribution and consumption stages and throughout the production and marketing chain. This could reduce the Swiss food industry's overall environmental impact by 10 to 15%.

A host of food supply concepts have been launched, with the emergence of start-ups such as Magic Tomato (Plan-les-Ouates, Canton of Geneva), which has developed a direct-flow shopping method that eliminates food waste and promotes independent food producers. Äss-Bar (Maur, Canton of Zurich) sells on unsold bakery produce. (Bakeries deliberately produce on average 10% more than they sell to enable them to have attractively stocked shelves right up to closing time.) The first outlet was opened in Bern, but this service is soon to be rolled out in all major Swiss cities. So-called social start-ups are also springing up, such as Le Radis cooperative (Bex, Canton of Vaud), which is self-managed by its members. This is one of many citizens' initiatives based on strong social values of paying a fair price to the producer and selling unpackaged, local, organic produce. The concept is catching on.

These companies have adopted a completely closed-cycle economic model, and this gives us a better idea of the impact and importance that the circular economy is going to have for society in the coming years. Most of these concepts begin life in a limited local area but can easily be applied and replicated at different scales depending on how far the project holders are willing to go. Their advantage is that they are easy to adapt to the context of the country or region to which they are deployed.

THE CATERING INDUSTRY

Schemes making use of leftover food from the catering industry are part of a well-organised sector that works in tandem with these food waste solutions. The idea of producing biogas from the anaerobic digestion of this waste may be a familiar one, but the success of these types of installations is also down to the collection and sorting system used. In this sector, SATOM (Monthey, Canton of Valais) has developed an innovative food waste collection 4.0 service which optimises the collection and quality of the waste, thereby reducing the CO₂ impact of the collection network.



© www.prix-pose.com

NEW MATERIALS

As mentioned above, some materials can be recycled and injected directly back into production, or repurposed. Research is also looking at new materials that take fewer resources or less energy to produce and which are easier to dispose of after use. An increasing number of initiatives are being developed in Switzerland, particularly involving biosourced materials. Bcomp (Fribourg, Canton of Fribourg) uses biosourcing for a whole series of applications (skis, car bodywork and aviation components – see page 63). Biosourced materials are also used in the Aventure racing car (La Neuveville, Canton of Bern) and the Softcar sister project (Fribourg, Canton of Fribourg), with both cars designed to be totally eco-friendly and fully biodegradable after use. FluidSolids (Zurich, Canton of Zurich) is also working on materials to replace plastics manufactured using fossil-fuel-based technology.

Besides biosourced materials, other new materials are being used to improve industrial processes. These new materials are less polluting during the production process and provide well documented energy savings, while improving the efficiency of industrial production. For example, the companies Advantec Polymers (Maur, Canton of Zurich) and Membrasenz (Ecublens, Canton of Vaud) are developing new materials for membranes used to filter and purify liquid and gas solutions.

Lastly, healable composite materials like the ones marketed by CompPair Technologies (Ecublens, Canton of Vaud) have a longer service life and can repair themselves. And Nanoleq (Zurich, Canton of Zurich) has developed an elastic material that conducts electricity, paving the way to a revolution involving what are already being called stretchable electronics.

³Study by ETH Zurich

INNOVATION PIPELINE

A host of Swiss companies and institutions are currently working on innovations. Here, we focus on a few new products and services with huge potential that are coming onto the market...



DEPOLY

The start-up DePoly has developed a chemical recycling technique for PET that is capable of recycling all containers – regardless of their original contents or colour – into their pure original constituents. This method saves nearly 7,000 litres of petroleum per tonne of PET produced and reduces the energy required to make new plastic by 66%.

www.depoly.ch



BATTRION

Battrion makes a new kind of batteries that cut charging times by up to 50%. What's more, when the batteries are charging and discharging they generate less heat, making them safer and longer-lasting. They are more powerful than conventional batteries, which makes them cheaper to use. This technology uses less-processed graphite particles, limiting waste and harmful effects on the environment.

www.battrion.com

UHCS – USTINOV HOFFMANN CONSTRUCTION SYSTEM

UHCS is developing a modular construction system made of recycled plastics including PET. It is designed to be manufactured on an industrial scale and then quickly assembled into a cubic post-and-beam structure with load-bearing walls, which can be tailored to local building traditions. This system creates a high-quality environmentally friendly construction that reduces humankind's impact on nature.

www.ustinovhoffmannconstructionssystem.com



AVENTOR

Aventor is an ultra-light electric racing car made of biopolymers and advanced composite materials. It is designed to be exemplary at every stage of its life cycle. Not a single chemical is used in building or decorating the car, and it is constructed exclusively from recyclable materials. Aventor opens the door to sustainable motor sports.

www.aventor.ch



VUNA

Vuna has developed technology that makes fertiliser out of human urine. This makes it possible to process and re-use wastewater locally, which is of particular value in isolated locations. The treatment process removes drug residues, hormones and microbes while retaining all the useful nutrients. Vuna fertiliser can be used to fertilise vegetables and flowers, which makes it the world's first fully certified urine-based fertiliser.

www.vuna.ch



FLUIDSOLIDS

The start-up FluidSolids offers a sustainable alternative to conventional petroleum-based plastics. The company's new degradable biocomposite materials have a minimal impact on the environment. Their fibrous structure gives them flexibility, solidity and elasticity which can be tailored to suit. The materials can easily be manufactured on an industrial scale.

www.fluidsolds.com

FIXIT

The company Fixit and the Swiss Federal Laboratories for Materials Science and Technology (EMPA) have developed a world first in the form of an insulating aerogel with a thermal conductivity of 28 W/mK. Dubbed Fixit 222, this thermo-insulating coating made up of more than 90% air is an effective insulator used mainly in refurbishing old apartment blocks and insulating historical buildings. Its mineral composition and high permeability to water vapour prevent mould formation. It is an eco-friendly alternative to polystyrene panels.

www.fixit.ch



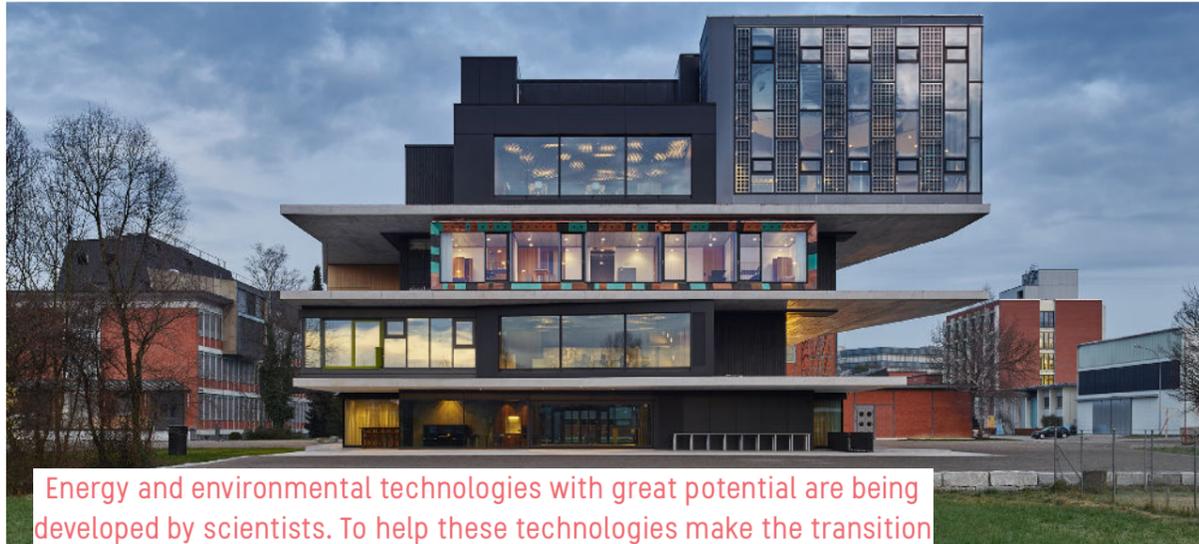
LOGBAU

Logbau has developed a new type of tarmac for road surfacing and stabilising earth that uses leftover tarmac and sawdust (the latter instead of cement). Since half of the binder mass is made up of sawdust, this halves the overall CO₂ impact of the binder. Also, a significant cost saving is made by the fact that the sawdust and excess tarmac does not have to be disposed of.

www.logbau.swiss



A glimpse of the future of energy



Energy and environmental technologies with great potential are being developed by scientists. To help these technologies make the transition to widespread use the Swiss Federal Laboratories for Materials Science and Technology (Empa) in Dübendorf (Canton of Zurich), set up the demonstration and testing platforms “NEST” and “move”.

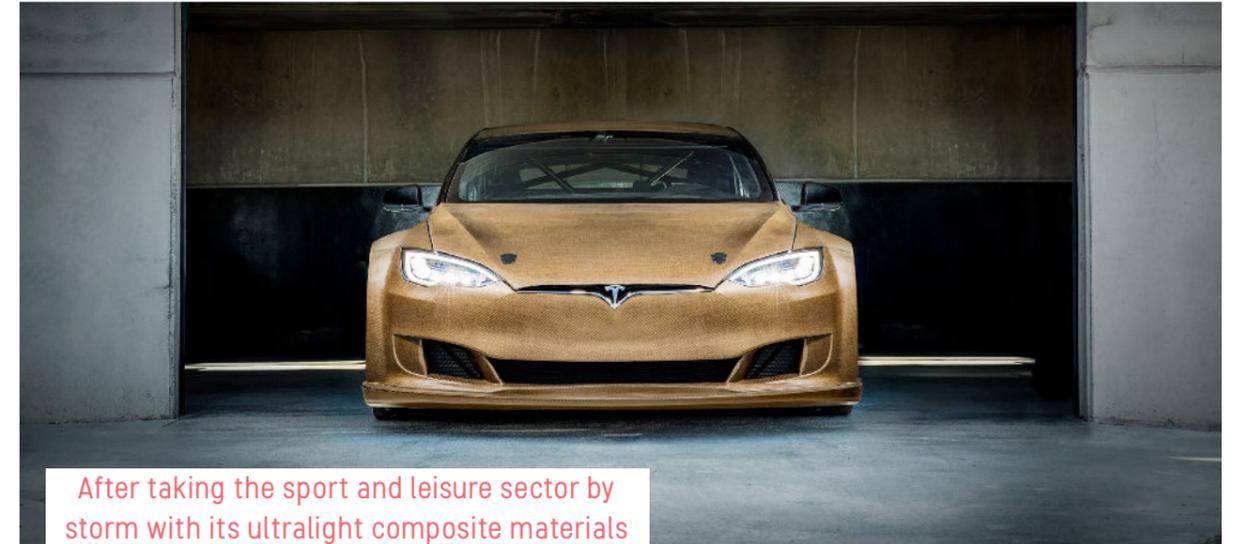
Getting industry to take up and commercialise the results of cutting-edge research requires a focused approach. In mid-2016, the four-storey NEST building opened on the Empa campus in Dübendorf. At NEST, Empa researchers work with industry partners to conduct practical tests on new energy and environmental technologies for the construction sector. One year before that, Empa launched the demonstration and testing platform move, which at its core comprises an electric charging station with stationary batteries and production, storage and refuelling facilities for hydrogen and methane. The aim is to demonstrate how fossil-fuel free mobility might work in practice.

Buildings and mobility account for three-quarters of final energy use in Switzerland, and the interest the Empa facilities attract from the public is correspondingly high. “The Empa platforms receive visits almost every day from businesses and experts interested in technical innovations and new operating models,” explains Empa mobility specialist Christian Bach. There is also interest from politicians and school/university students, as well as increasingly from investors, insurance companies and banks. At Empa, they can get a preview of the future of energy supply. One NEST project, for instance, is investigating the long-term durability of the flame-resistant wood developed by Empa, which will be used as a sustainable

material in future building projects. Meanwhile, move is testing an industry partner’s prototype for a hydrogen refuelling solution.

These are just two out of several dozen NEST and move projects. One link between the two platforms is the Energy Hub, ehub for short, where researchers investigate district-level energy management and the potential for combining building and mobility applications. The Empa experts’ work isn’t just limited to demonstrating new technologies; they have also, for example, worked with relevant licensing and testing authorities and specialist bodies to produce guidelines on hydrogen station licensing – a crucial factor for the expansion of hydrogen technology and sustainable mobility.

Bcomp: lightening the load for future mobility



After taking the sport and leisure sector by storm with its ultralight composite materials containing flax fibres, Bcomp (in Fribourg) has now grabbed the attention of the motor and aeronautical industries.

Durable, strong and light. These three adjectives best describe the properties of the plant-fibre-based materials developed by Bcomp. Established in 2011, the company has amassed an in-depth knowledge of how flax performs in different composite materials. “The uniqueness of our biocomposites is down to the way we structure the fibres to create a high-tech material,” explains CEO Christian Fischer. The technology patented by Bcomp consists of a mesh that can be mixed with different resins to strengthen thin-walled structures, making them significantly lighter than standard materials.

Ski manufacturers were the first to get excited about these properties, and a third of Bcomp’s earnings are in the sport and leisure sector, with a presence in Europe, South America and to a lesser extent China. Bcomp has also made a big impact in motor sports, their flax fibre solution performing just as well as carbon but costing 30% less and generating 75% lower CO₂ emissions on average. And it is in the field of mobility that Bcomp has a huge growth potential today.

Lighter = more fuel-efficient

Bcomp is already working with a number of commercial motor manufacturers – hardly surprising when their biocomposite components are 40% lighter than those made of standard materials, thus reducing fuel

consumption. A very timely solution given that the European Union is imposing drastic vehicle CO₂ emission reductions on the motor industry. And to satisfy the same demand for lighter components, Bcomp is taking part in a major project to manufacture internal parts for aircraft cabins. Lastly, it is worth mentioning that the company has been developing ultralight satellite components with the European Space Agency (ESA) for some years now.

As a result, Bcomp has won several awards for its innovative products. In Christian Fischer’s view, the most prestigious award received so far is the Swiss Economic Award, in 2016, because this award demands particularly high standards of due diligence. Other major industrial awards won by Bcomp include two JEC Innovation Awards, in 2014 and 2018. We haven’t heard the last from them...

Disaggregation process uses ‘lightning’ to separate waste



Thermal recycling of household waste generates slag which has to be disposed of in special landfill sites. SELFRAG (in Kerzers, Canton of Fribourg) uses an innovative high-voltage electrical process to reclaim the metals and other valuable recyclable materials from this slag, thereby reducing the amount of waste generated.

“Ideally, we would like to be able to treat waste so efficiently that we can reclaim all the source materials, thereby generating zero waste.” This is the ultimate goal of Frédéric von der Weid and his company SELFRAG, a 2007 spin-off of the Langenthal-based Ammann Group that today employs a workforce of 30. The company has industrialised a process that uses pulses of high-voltage electricity to break down materials into their component parts. “Our process works in the same way as a bolt of lightning splitting a tree,” explains CEO Frédéric von der Weid, drawing a graphic comparison.

Up to now, high-voltage disaggregation has only been used to any great extent in research and the semiconductor industry. For these applications, the Fribourg-based company has already sold more than 40 installations worldwide. SELFRAG’s bosses now see the future key application of this technology as being in the waste-processing industry, because almost 100% of metals and low-polluting construction waste can be reclaimed from slag using this high-voltage process.

The slag produced by incinerating household waste contains a number of valuable materials: one tonne of waste contains on average 7 kilograms of valuable copper, for example. The SELFRAG process makes it possible to recycle these kinds of high-worth materials and at the

same time reduces the quantity of slag by around a quarter. In the future, Frédéric von der Weid thinks it will be possible to cut the amount of slag by as much as half.

This environmental technology has been in use at the waste incineration plant in Posieux near Fribourg since spring 2017, and SELFRAG plans to sell more installations in Switzerland. There are important export markets for this technology in Germany, Scandinavia and the US. In all these countries, most or at least some household waste is incinerated and not disposed of in landfill, as it is in Brazil and China for example.

SELFRAG’s business model is based on selling installations and operating them in-house. It is also looking at processing slag already in landfill to reclaim the valuable materials it contains and create additional space on landfill sites that are already over capacity.

SELFRAG
www.selfrag.com



© Batrec



“MPS develops high-tech microsystems while limiting its carbon footprint through significant day-to-day initiatives such as installing solar power plants and optimising our electricity consumption.”

Nicola Thibaudeau

CEO of MPS Micro Precision Systems and member of the Executive Board of Innosuisse



Environmental technologies

The scope of Swiss environmental technology applications and expertise is vast. In this report we shall therefore focus on water treatment, air quality and management of natural disasters, three separate fields in which Switzerland excels. Of all the planet's natural resources, it is air, earth and water that are essential for the well-being of society. And yet, these three elements are under tremendous pressure, and this pressure is set to increase with our ever-growing population and economic activity.

Water is essential to life and health. It is a common resource, but today 750 million people worldwide do not have access to clean drinking water and have to make do with an unsafe supply, according to UNICEF. No fewer than 3.6 million people, more than two million of them children, die every year due to a lack of safe water. This is the leading non-age-related cause of death, according to the World Health Organization.

The issues relating to hygiene and sanitation are common throughout the world, with challenges arising from local conditions. The basic problem of contamination remains very similar everywhere, although contaminants vary depending on the regions and infrastructures concerned. They range from pathogenic bacteria to micropollutants and hormones, which require more complex and more costly treatment.

Similarly, an excess of fertilisers, whether natural or synthetic, or any other kind of ground contamination can lead to water pollution, becoming a public health issue in the short or longer term.

In this context, it is obvious that environmental technologies have a crucial role to play, and solutions that protect our water resources, improve air quality, reduce ground pollution and lessen the impact of greenhouse gases are now an essential part of all our lives. And not forgetting of course technologies developed to mitigate natural disasters, which are becoming increasingly important with the effects of climate change. Switzerland has developed cutting-edge innovations in all of these fields.

WATER MANAGEMENT AND TREATMENT

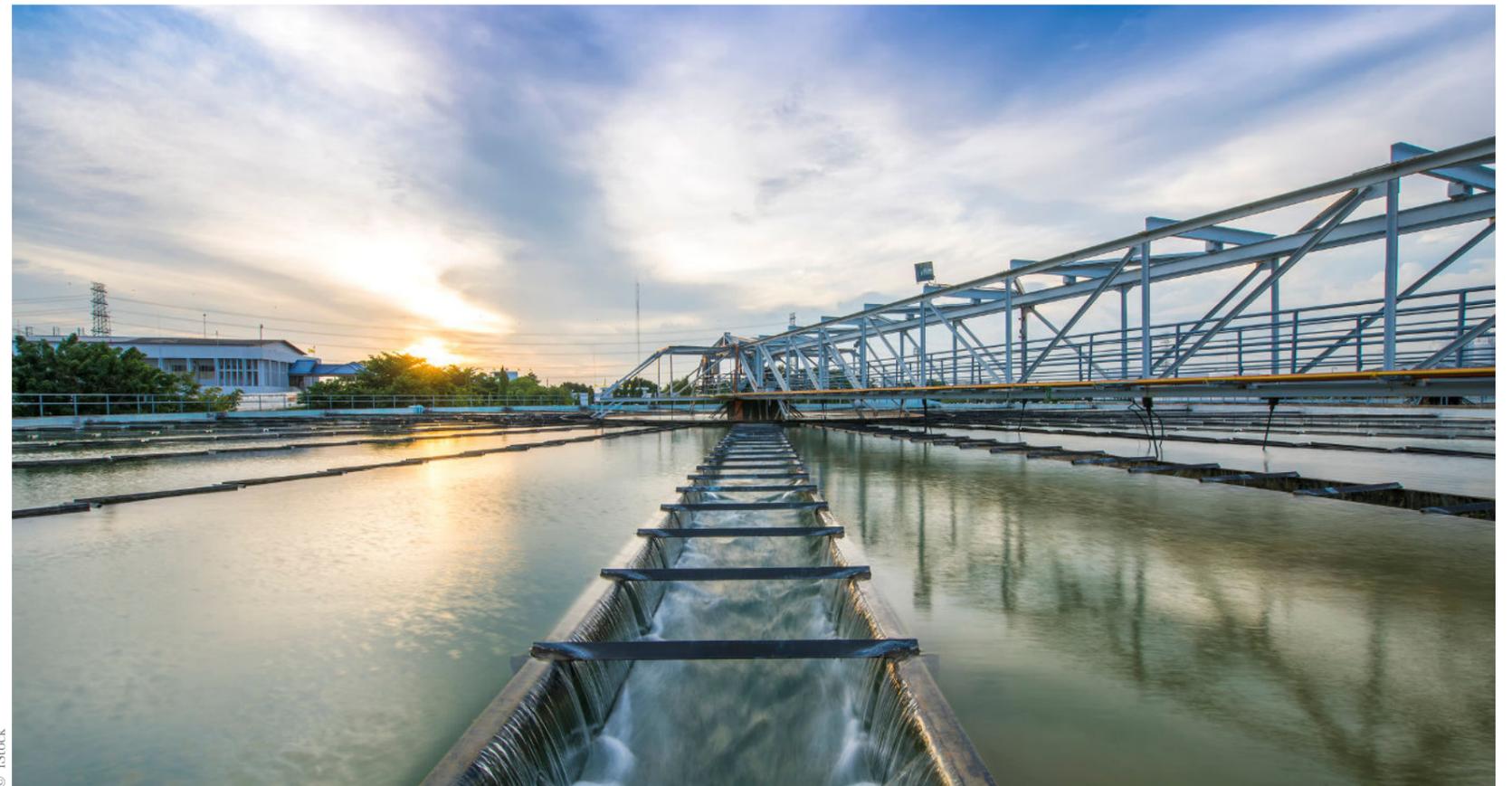
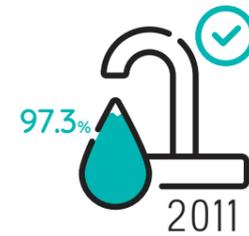
Switzerland has particularly abundant water resources which must be protected and exploited carefully and responsibly. Often described as Europe's water tower, the country has a duty to ensure the good quality and supply of the water running off its territory. With its experience and expertise, Switzerland is in a position to export its tried-and-trusted technology in this field to other countries. This applies to the production of drinking water, irrigation, and the collection and treatment of wastewater.

Regarding the treatment of wastewater, in 1965 only 14% of people living in Switzerland were connected to a municipal water treatment plant. By 2011 this figure had reached 97.3% and it has not changed since, according to the Swiss Federal Office for the Environment. The roughly two percent remaining are not shown in the records as connected because these people live in remote and sparsely populated areas. Consequently, Switzerland has achieved 100% of its potential, which is a worldwide record. The main challenge today is to ensure the sustainable treatment of wastewater and improve treatment systems, particularly with regard to removing micropollutants more effectively.

Switzerland is also teeming with ideas and developing a host of solutions when it comes to filtration systems. Trunz Water Systems (Steinach, Canton of St Gallen) markets treatment units in mobile and static installations for fresh, brackish and seawater in over 30 countries on four continents. The SME Membrattec (Sierre, Canton of Valais) manufactures ultrafiltration systems combining reverse osmosis and nanofiltration for the production of drinking water for public authorities, and Etertub (Bilten, Canton of Glarus) markets a slow sand filtration system that does not require an energy supply, developed together with RWB (Porrentruy, Canton of Jura) (see page 80).

But the expertise of Switzerland's industrial fabric is not limited to filtration. Smixin (Biel/Bienne, Canton of Bern) and Swiss Eco Line (Chur, Canton of Graubünden) market water-saving handwashing systems, and NVTerra (Monthey, Canton of Valais) has developed a treatment system that produces drinking water using only natural materials (iron, salt and electricity) which is capable of treating water contaminated with arsenic. Swiss Fresh Water (Romanel-sur-Lausanne, Canton of Vaud) manufactures water stalls, a low-cost, self-sufficient treatment solution for brackish water. More than 130 of the company's units are in use in Senegal.

SWISS PEOPLE CONNECTED TO A MUNICIPAL WATER TREATMENT PLANT



Madep (Bevaix, Canton of Neuchâtel) uses microorganisms to combat water pollution. When it comes to treating effluent and wastewater discharged from industrial processes, NGL (Nyon, Canton of Vaud) exports its solutions to three continents. In a similar vein, HeiQ Materials (Schlieren, Canton of Zurich) markets to fabric manufacturers a synthetic-fibre-dyeing process that saves energy and water (see page 81) and Sedo Engineering (Riddes, Canton of Valais) has developed new technology for the denim industry. Their Smart Indigo technology is revolutionising the jeans-manufacturing industry with an electrochemical process that replaces chemicals with electricity, drastically reducing the industry's water-polluting impact.

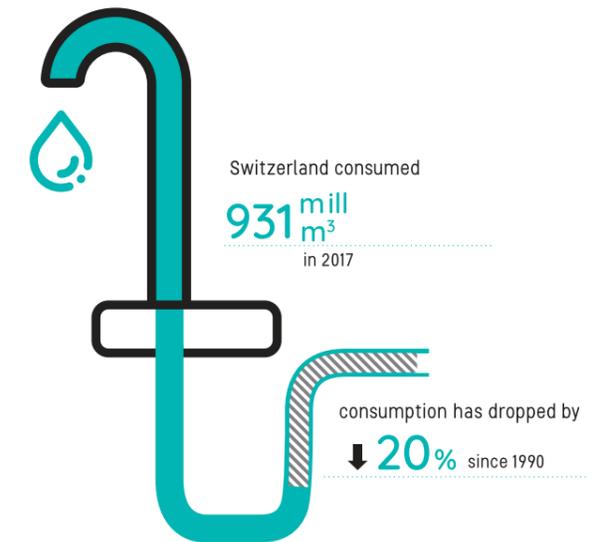
In farming, the SME Aqua-4D (Sierre, Canton of Valais) markets a system that uses electromagnetic waves to treat water in more than 40 countries. Used on farms, this solution offers improved biosecurity because it has been shown to eliminate biofilm formation and inhibit the re-growth of bacteria. The system also makes major water savings, solves the problem of salinity and prevents the build-up of biofilms and minerals in irrigation systems while improving yields and produce quality.

Swiss companies are also developing smart water management software for applications such as irrigation and farming. Hydrosolutions (Zurich, Canton of Zurich) and Droople (Puidoux, Canton of Vaud) are two such companies. These software products meet a range of needs, from helping to manage water resources in developing countries to tackling wastage in large urban centres. Several solutions for on-line prevention of contaminated water are also being developed in Switzerland. Companies working in this field include Metanor (Regensdorf, Canton of Zurich) and bNovate (Ecublens, Canton of Vaud), which has developed BactoSense, a product marketed by Sigris-Photometer (Ennetbürgen, Canton of Nidwald) and now also sold further afield in Asia and the USA.

Research and development for the water industry is overseen by the Swiss Federal Institute of Aquatic Science and Technology (Eawag). Other research is being carried out by subject-specialist units at the University of Applied Sciences and Arts Western Switzerland (HES-SO), the Federal Institute of Technology in Lausanne (EPFL) and various universities.

The actions of the various players in this field are now closely coordinated by the Swiss Water Partnership, which promotes Switzerland's voice abroad in facilitating dialogue and governance in the water industry. The Swiss Water Partnership represents the interests of public, private and parapublic bodies (NGOs) and other industry players.

WATER CONSUMPTION IN SWITZERLAND¹



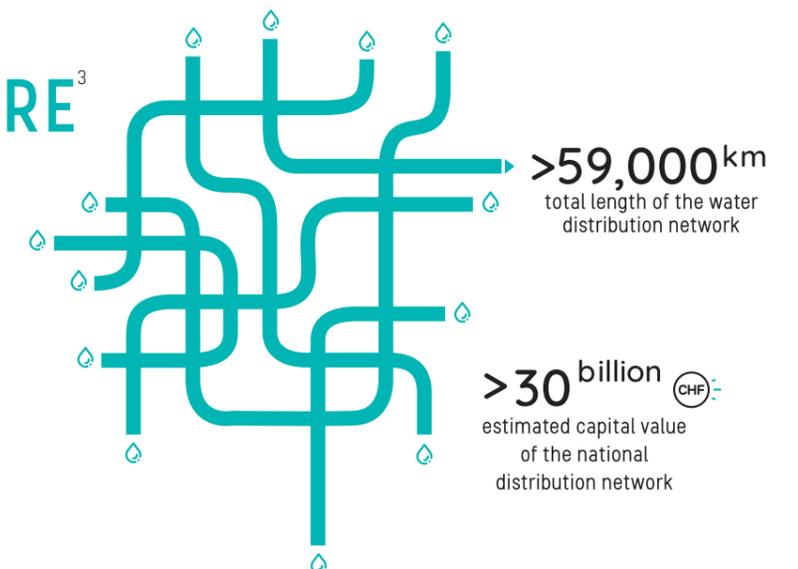
472 litres/day in 1990

301 litres/day in 2017



CONSUMPTION OF DRINKING WATER PER PERSON²

WATER INFRASTRUCTURE³



¹ 2018 water supply statistics - Swiss Gas and Water Industry Association (SSIGE)

²⁻³ Federal Statistical Office (FSO)

AIR QUALITY

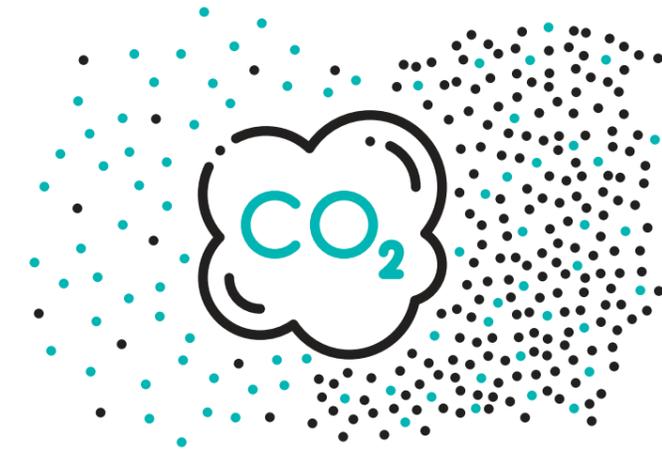
Greenhouse gas emissions are one of the biggest environmental challenges our planet faces. Compared to the other OECD member states, Switzerland emits lower levels of greenhouse gases on its national territory. This is down to the fact that its electricity industry, made up mainly of hydroelectric and nuclear power plants, generates practically zero CO₂ emissions within the country, and that heavy industry accounts for a relatively small part of the economy. This also partly explains the country's performance in terms of resource productivity (see page 52, the chapter on Advanced and Recycled Materials). Nevertheless, at 14 tonnes of CO₂ equivalent per person per year, Switzerland's greenhouse gas footprint is by no means insignificant. At eight tonnes of CO₂ equivalent per person per year, Switzerland's total emissions generated both at home and abroad by the nation's consumption are even well above the world average, which stands at around six tonnes of CO₂ equivalent per person per year.

Switzerland has therefore decided to act. By 2030, the country is aiming to reduce its greenhouse gas emissions by a minimum of 30% compared to 1990, according to a proposal by the Federal Council. The CO₂ Act is currently being completely revised to this end and will no doubt result in a fair amount of debate in the coming years over all the regulations needed to implement it.

In parallel, innovative technologies are being developed to reduce emissions, particularly those caused by heating homes. One example of this is OekoSolve (Mels, Canton of St Gallen) and its electrostatic filters designed to remove fine particulates (see page 79), and another is Fireforce Technology (Orbe, Canton of Vaud), whose combustion system drastically reduces the quantity of fine particulates emitted by wood-pellet-fired systems without the need for special filters. Other companies are also introducing carbon capture and sequestration initiatives, such as Climeworks (Zurich, Canton of Zurich), which is developing technology designed to contribute to a 'net-zero-emission world' (see page 79).

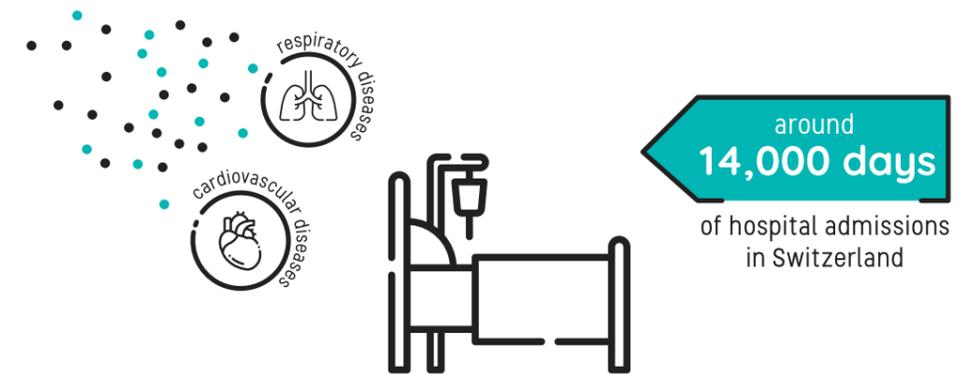
Fresh air is also an important part of Switzerland's reputation around the world. Companies such as Zehnder Systems (Gränichen, Canton of Aargau), make dust-filtration units for industry. To deal with the internal combustion engine, Baumot (Spreitenbach, Canton of Aargau) markets particle filters, and Liebherr Machines (Bulle, Canton of Fribourg) has developed an innovative compact processing system for diesel exhaust gases that combines particle filter functionality with selective catalytic reduction (SCR).

In the field of public health, Plair (Geneva, Canton of Geneva) supplies local authorities with continuous measurement devices that monitor levels of pollen, bioaerosols and contaminants (see page 78).



fine dust contains nearly
50 times less
lead than it did 30 years ago¹

DISEASES CAUSED BY AIR POLLUTION



EVERY YEAR, AIR POLLUTION CAUSES DEATHS



¹National Air Pollution Monitoring Network (NABEL) annual report

²Federal Office of Public Health

³World Health Organization

NATURAL DISASTERS

Natural disasters (floods, debris flows, landslides, rockslides, rock-falls, high-water damage, etc.) have always been a significant hazard with major consequences in Switzerland. In many places around the country, these natural hazards represent a considerable threat to human life, infrastructures and property. The existing threat is exacerbated by an increasing amount of urban development in at-risk areas and the acceleration of the effects of climate change. In 2016, one Swiss in eight lived in a flood zone. The measures introduced since then are helping to reduce this number drastically. The increase in the value of at-risk infrastructures is becoming a matter of concern in many regions. Insurance companies and reinsurers like Swiss Re are keeping a close eye on changes in this sector and the technology being developed in the field.

The main climate change factors that influence these natural disasters are the increasing frequency and intensity of extreme hydrometeorological events (short periods of torrential rain) and the repercussions of the increase in temperatures. The most striking manifestation of these changes is perhaps the Alps' shrinking glaciers. The large-scale loss of glacier volume is causing changes such as the formation of glacial lakes and pockets that threaten the land below.



318 mill ^{CHF} the cost of severe weather events

At the end of 2018, avalanche risk management was added to the Intangible Cultural Heritage List. This recognition by UNESCO acknowledges the way that traditional knowledge, technology and popular culture complement each other to form part of our intangible cultural heritage.

Some Swiss companies, such as Wyssen Avalanche Control (Reichenbach im Kandertal, Canton of Bern) and Gaiasens (Martigny, Canton of Valais), which sets up monitoring stations (see page 78), have specialised in this field. There is also PermaSense, a research consortium of scientists working in different engineering and environmental research disciplines. Working with the Swiss Federal Institute of Technology and University of Zurich, it deploys wireless detection systems at high altitude, on mountains such as the Matterhorn (Zermatt) and the Aiguilles du Midi (Chamonix). In addition to this core aspect of its work, the consortium is developing methods and tools for studying and quantifying the link between climate, permafrost, glaciers, snow and geological movements. Regarding water resource management more generally, the hydrology consultancy Hydrique Ingénieurs (Le Mont-sur-Lausanne, Canton of Vaud), which also has an office in the French region of Auvergne-Rhône-Alpes, is a good example of the contribution that digitalisation and artificial intelligence make in this field. The company's services include providing real-time forecasting information, in particular for the management of water catchment areas (optimising hydroelectric turbine operation, flood forecasting, etc.).

Lastly, Geobrugg (Brugg, Canton of Aargau) is a world leader in the supply of safety nets and meshes made of ultra-high-strength steel cable, very useful in protecting infrastructures and population centres from natural hazards.

Research and development in the field of natural hazards is overseen by the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), whose remit includes forests, landscapes, biodiversity, natural hazards and snow and ice. Other research is carried out by subject-specialist units in the country's Federal Institutes of Technology and various universities, such as Alpole (see page 83).

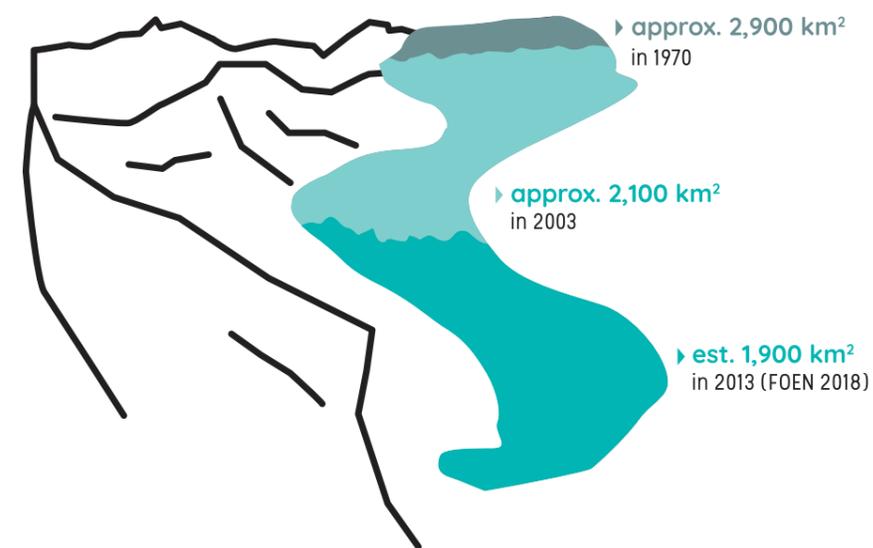
not including damage caused by



By 2050, the damage caused to Swiss infrastructures and production losses affecting the country's energy infrastructures will cost the economy around

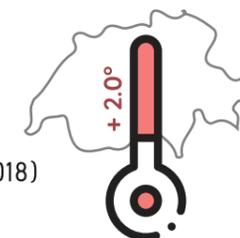
one billion ^{CHF} per year⁴

This is what it will cost the country to maintain a public transport network worthy of the name.



SHRINKING GLACIERS
THE APPROXIMATE SURFACE AREA OF THE COUNTRY'S GLACIERS

Between 1864 and 2016, the average temperature in Switzerland has increased by **+2.0 degrees Celsius** compared to +0.9 degrees Celsius globally (FOEN 2018)



⁴ Study by the Department of Transport, 2019

INNOVATION PIPELINE

A host of Swiss companies and institutions are currently working on innovations. Here, we focus on a few new products and services with huge potential that are coming onto the market...



© Gaiasens Technologies

GAIASENS TECHNOLOGIES

Gaiasens Technologies develops operational solutions for managing natural hazards, including high-tech monitoring stations that provide real-time measurements. These stations are designed to function autonomously in extreme environments such as those found at very high altitudes. The company also offers environmental modelling to help understand natural phenomena.

www.gaiasens.ch

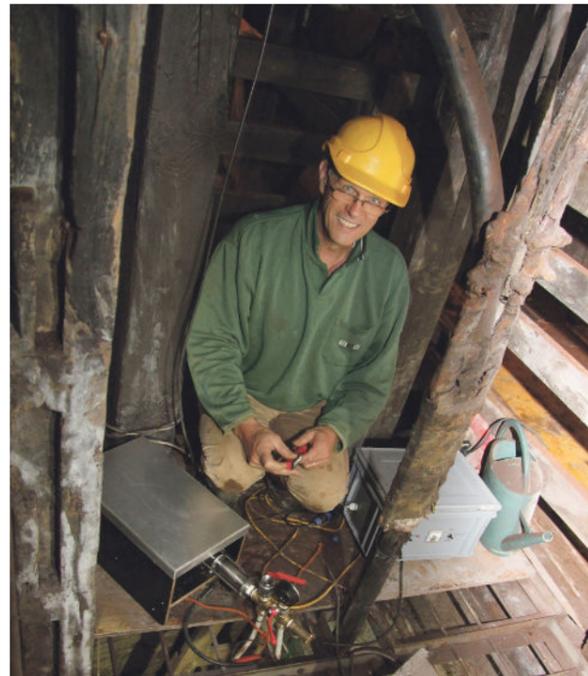
METANOR

Metanor has developed an on-line water analysis system that measures bacteria levels. It is designed to operate continually, 24 hours a day, seven days a week. The device will take measurements without human intervention for at least two weeks.

www.metanor.com



© Metanor



© Swiss Intech

SWISS INTECH

Swiss Intech has developed a self-powering pumping system capable of pumping water from a depth of up to 80 metres. This solar-powered system is designed for use in areas with no water infrastructure and mountainous regions all over the world. The tubular pump is very small (only 40 mm in diameter). It requires no more energy to work than an electric light bulb.

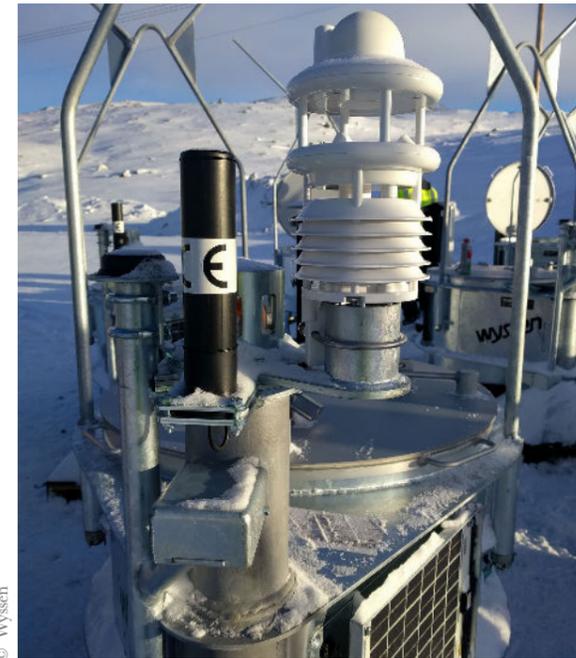
www.swissintech.ch



PLAIR

Plair SA transforms air quality monitoring across multiple industries. Plair SA has developed a proprietary and patented laser-sensing system for precise air quality monitoring and instantaneous detection of pathogens, allergens, and pollutants. The Plair system replaces microbial identification and particulate counting, increasing efficiencies, automation, and enabling improved risk management related to biocontamination.

www.plair.ch



© Wyssen

WYSSEN AVALANCHE CONTROL

Wyssen has been working in avalanche hazard prevention since 1926. It supplies remote avalanche-directing systems. The market leader in Switzerland, Austria and Norway, it also supplies installations to protect not only ski resorts but also roads and mines in Canada, the United States and Chile.

www.wyssenavalanche.com



SIGRIST-PHOTOMETER / BNOVATE

bNovate SA, in partnership with the company Sigris-Photometer, markets a revolutionary microbiological monitoring instrument for the drinking water industry: BactoSense. This instrument reduces the measuring time from several days to just 20 minutes, which means that the number of bacteria present can be monitored automatically 24 hours a day, before the water is supplied to customers. bNovate is thus making drinking water safer for consumers and tackling a considerable public health risk at the same time.

www.photometer.com www.bnovate.com

CLIMEWORKS

Working with its partners CarbFix2 and Reykjavik Energy, Climeworks has developed a technology that captures CO₂ from the air, mixes it with water and transports it 700 metres underground. When it is brought into contact with a volcanic rock, the solution turns into limestone, making it no longer harmful to the environment. Using this process, the company hopes to capture 1% of worldwide CO₂ emissions by 2025.

www.climeworks.com

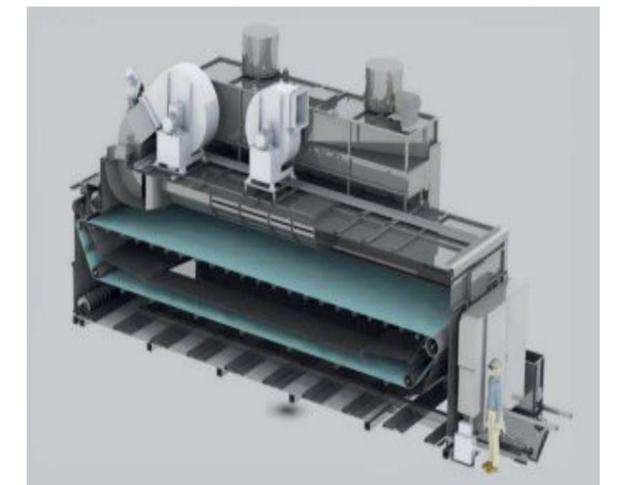


© Climeworks

OEKOSOLVE

Known mainly for its electrostatic filters that limit fine-particulate emissions, OekoSolve has also developed an innovative solution for biomass-to-energy systems. Neviro is a single system that combines drying the fuel with reducing emissions of the fine particulates it produces. It uses the energy in the exhaust gas to dry the fuel burned subsequently, thereby increasing the installation's yield.

www.oekosolve.ch



The KLS filter – drinking water with no need for electricity or chemicals



The engineering company RWB (in Porrentruy, Canton of Jura) has devised a water filtration system that uses no electricity or added chemicals. Used successfully in mountainous areas in Switzerland, this solution has promise for applications in emerging countries.

RWB Groupe is an engineering company active mainly in the field of water management and water treatment. First used in 2002, the KLS filter was designed by the group's vice-chairman Daniel Urfer. It is manufactured in partnership with the Swiss company Etertub. The KLS filter can be used to treat water in remote locations that are not connected to a drinking water system. It removes all undissolved particles including bacteria and suspended matter effectively without the need for electricity or chemicals, by means of a device that is easy to maintain.

Initially developed to treat around 5,000 litres a day (the water consumption of a medium-sized farm or a small hamlet), the system is now also available in a more compact version capable of filtering between 500 and 700 litres a day, suitable for a mountain hut, a remote chalet or remote dwelling for example. The largest installations can treat up to 30,000 litres a day.

A solution with promise for developing countries

The device makes use of tried-and-trusted gravel-filtration and slow-sand-filtration technology. But what make the KLS filter unique is its use of bauxite, and RWB has filed a patent for its design. Around 20 KLS filters are currently in use in Switzerland, mainly in mountainous regions. These installations are used in most cases to treat water from private springs that is otherwise unfit

for consumption. The device is also useful for treating contaminated rainwater from rooftops which has a very low mineral content.

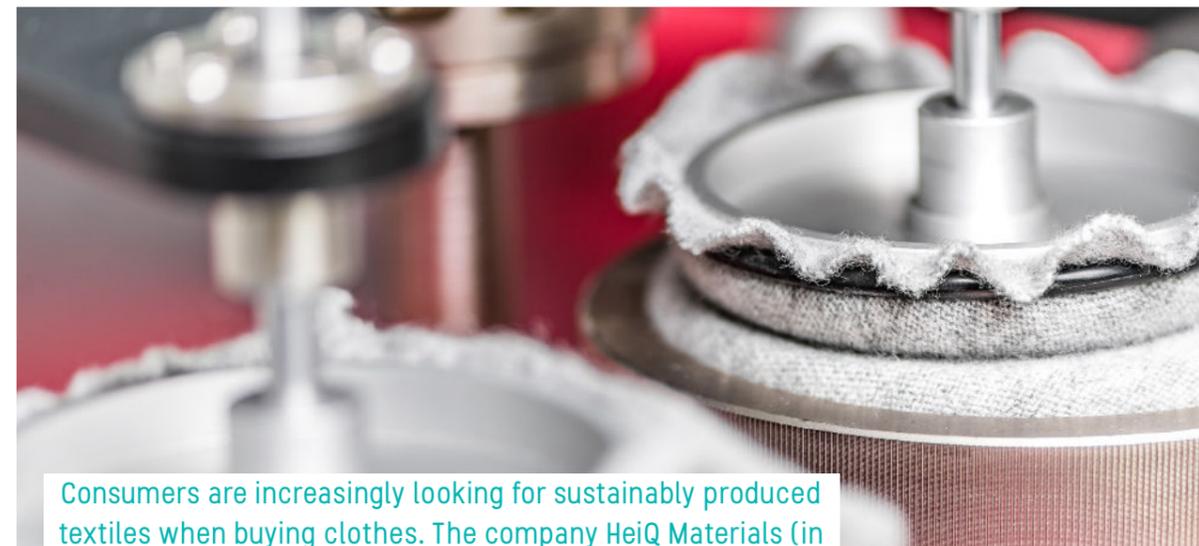
The future of the KLS in new markets is already becoming clear, and in sustainable development the KLS filter is showing most promise in applications abroad. Two filters have already been installed in Africa, one in Burkina Faso and the other in Guinea, to tackle the major problems of water turbidity and contamination by pathogenic microorganisms. "To provide a truly sustainable solution, ideally we should manufacture locally for the local market," says Daniel Urfer, who would like to see this technology becoming fully transferable. This sustainable aspect is very important to RWB, which wants to see guaranteed access to drinking water for all at an affordable cost. "We are first and foremost scientists who believe that the most important thing is to provide concrete solutions."

Etertub

www.ertub.com

www.rwbgruppe.ch/eau/kls-filter/presentation

Green textiles of all colours



Consumers are increasingly looking for sustainably produced textiles when buying clothes. The company HeiQ Materials (in Schlieren, Canton of Zurich), has developed a process that enables textiles manufacturers to dye synthetic fibres saving not only time but also energy and water.

Top athletes and many amateur sports lovers alike swear by specialist underwear made from textiles that prevent the build-up of sweaty odours, repel water and ensure optimum temperature regulation. Textile manufacturers use some innovative processes to produce such fabrics, including one from HeiQ Materials AG. Carlo Centonze and Dr. Murray Height founded the company in 2005 as a spin-off from the Swiss Federal Institute of Technology (ETH) in Zurich. The company now employs 80 people, and its customers include textiles manufacturers in Italy, Turkey, the USA and a number of Asian countries. The clothes made from these manufacturers' textiles are sold worldwide.

The global production of textiles is huge, and the leverage from the use of environmentally sustainable processes is commensurate in this business sector. One such process is the "HeiQ Clean Tech" system, which is used in the dyeing of polyesters. It not only saves time for textile manufacturers, but also reduces their water and energy consumption by 30% in comparison with standard processes. To date, HeiQ has supplied the process to customers in countries as far afield as Turkey and China. The innovative technical process earned the company the Environmental Business Award from the Swiss Environmental Foundation in 2019.

The environment also benefits from other HeiQ processes, including the manufacture of water-repellent textiles without the use of damaging PFCs (perfluorinated compounds and polyfluoroalkyl chemicals). As reduced odour build-up enables clothes to be washed less frequently, this saves the valuable resource of water and reduces pollution. This substantial impact is the result of many years of investment by HeiQ in the company's development. A milestone on the way to the firm's success was provided by the Swiss sportswear manufacturer Odlo – the custom of this well-known company in HeiQ's early days enabled the newcomer to gain a valuable foothold in the competitive textiles market, and to make a name for itself.

HeiQ
heiq.com

Wire mesh vs climate change



High-tensile steel wire meshes from Geobrugg (in Romanshorn, Canton of Thurgau) have been proving their worth for decades as a protective measure against rockfalls, landslides and other natural hazards. In future, the company's products could also help mitigate the effects of climate change.

Wire-mesh fences aren't something that would normally be considered a high-tech product, but the highly robust steel meshes manufactured by Geobrugg are a good example of how decades of development can turn a seemingly simple product into a byword for outstanding quality – and propel a Swiss manufacturer to the status of global market leader. The company's wire-mesh nets were first used in 1951 to provide protection from avalanches, and later on to protect against rockfalls. They've been continuously improved ever since. In 1999, an innovative production method was introduced that allowed meshes to be manufactured using high-tensile steel wire with exceptional protective properties and corrosion resistance, which means they are able to provide protection from rockfalls, land- and mudslides and avalanches. These meshes are used for safety applications in mining and tunnel construction and on motorsport courses.

Geobrugg AG is a subsidiary of the Brugg Group, an international manufacturing group. It has been a standalone public company since 2008. Around half of its 300+ employees work in Switzerland, and it has a presence in almost 50 countries, either directly or through sales partners. Geobrugg built up an international manufacturing base from an early stage, with plants in countries including the USA, China and Japan. But Switzerland continues to play a central role in the company's manu-

facturing operations and R&D activities, with numerous test facilities located in the country. The most famous is in a former quarry by Lake Walen, where Geobrugg steel meshes demonstrated that they were capable of withstanding a 25-tonne concrete block travelling at 100 km/h.

Possible measures to protect against rockfalls, landslides and other natural hazards include concrete walls, dams and shotcrete-reinforced slopes. "Our steel meshes provide the same level of protection but without the need for large quantities of concrete, which means they have a far lower carbon footprint," explains CEO Andrea Roth. The next challenge will come from climate change: extreme weather events like heavy rain are expected to increase, while the thawing of permafrost will lead to more mudslides and rockfalls. That means demand for Geobrugg's protective systems is likely to keep on growing.

Geobrugg
www.geobrugg.com

Energypolis, an ambitious campus combining research and commercial applications



In view of its climate and distinctive mountainous terrain, the Valais canton was always destined to play a leading role in the energy transition. And with its status as a green energy powerhouse, the region and Energypolis Campus (Sion, Canton of Valais) form the cornerstone of an innovation ecosystem that addresses the challenges posed by climate change.

This ambitious project involving an investment of more than 400 million Swiss francs is promoting a concept at the cutting edge of innovation, bringing together players in fundamental research, applied research and the development of commercial applications. This innovation chain for the energy, environment and health-care sectors combines the forces of EPFL Valais-Wallis, HES-SO Valais-Wallis and The Ark Foundation. As a result, Energypolis is a unique partnership unrivalled in Switzerland, bringing together on the same site a federal institute of technology and a university of applied sciences to create a powerful synergy.

With the energy and environmental challenges that we face, Energypolis is working to create a vision of tomorrow's Switzerland. This campus is a driving force in efforts to devise concrete solutions for storage, energy conversion, mobility, new materials (for insulation, environmental decontamination, photovoltaic cells, etc.) and developing advanced energy generation and chemical processes. It is also active in the sector of hydrogen.

Concrete solutions to climate change

In the search for solutions, start-ups like GRZ Technologies (developing a hydrogen storage solution that uses metal hydrides), ExerGo (CO₂-based heating and air-conditioning systems), DynaBlue (using thermal flow

sensors to improve the efficiency of industrial processes), DePoly (depolymerisation of PET), UHCS (a modular construction system that uses recycled PET), and Urbio (the urban planning software of the future, incorporating energy transition requirements), show that the approach adopted by Energypolis is the right one. The campus and its incubator foster the development of concrete solutions which are the result of a concerted dialogue between academic and economic players that takes full account of the industrial fabric.

This model is both relevant and attractive, as demonstrated by the recent arrival at Energypolis of the Swiss Polar Institute (SPI), a body of the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), and the Alpine and Polar Environment Research Center (ALPOLE), which is working on strategies to mitigate or adapt to the impacts of climate change on the environment. The work currently being carried out in these institutes has for example revealed the part that mountain watercourses play in transporting the CO₂ released by melting glaciers.

Energypolis
www.energypolis.ch

Urban solutions & energy systems



URBAN SOLUTIONS &
ENERGY SYSTEMS

The world population is currently around 7.8 billion people, and according to the UN it could approach the 10 billion mark by 2050. More than half of the planet's population already lives in urban areas, and the trend is set to increase. This represents a considerable challenge, also for Switzerland, where three-quarters of the population lives in urban areas. These urban areas are responsible for the majority of the country's energy consumption and CO₂ emissions. The building stock alone accounts for around 45% of the nation's final energy consumption. This state of affairs highlights the impact that innovation in this field can have, in particular in developing buildings and ecodistricts to become energy plants in their own right that are capable of being largely energy-self-sufficient. This urban growth, combined with the climate emergency, is having undeniable effects in the wake of the Paris Agreement at the end of 2015.

A response to this situation is given by a combination of the following elements:

- reduction of greenhouse gas emissions;
- development of more resilient infrastructures;
- evolution to a more sustainable society.

What this means in practical terms is that Switzerland has to achieve its energy transition, capitalise on the digitalisation of the economy and adopt long-term sustainable development objectives, with the goal of becoming a net-zero-greenhouse-gas-emission society by 2050.

WORKING TOWARDS URBAN RESILIENCE

The options on the table for the first prong of the national strategy are familiar ones, namely identifying and making use of relevant alternatives to fossil energy sources.

When it comes to developing resilient infrastructures, in particular transport links and the supply and distribution of energy and water, the challenge is not so straightforward. The key is to ensure that these infrastructure networks are interconnected through the elements comprising them, from the smallest part (such as an inverter) to the largest (an ecodistrict) and including batteries, photovoltaic panels and buildings. In other words, the resilience of our towns, urban centres and ultimately the whole country depends on our ability to transform the country's infrastructure into a network of interconnected microgrids.

And lastly, regarding sustainability, our thinking is becoming geared towards more upgradable and flexible infrastructures and systems. These must be able to evolve into future-proof infrastructures involving a strong digital component while remaining upgradable without requiring large-scale investment in the short term.



SWITZERLAND'S SOLUTIONS

In May 2017, the Swiss citizens formally agreed to the legal framework necessary to achieve the 2050 energy transition with the revised energy law. The fundamental transition that Switzerland has begun is in response to a major challenge, namely the need to take control of the development of the urban environment and its related energy systems. In this report, we present a few striking examples of energy solutions and systems that address this issue. These and other solutions are already available on the market; they must now be rolled out on a larger scale in Switzerland and abroad. Future improvements and new innovations will further accelerate the rate of change and ensure we can meet the goals and challenges.

Both regionally and in individual urban centres, two main levels can be identified. The first of these is made up of the infrastructures (transport links, water and waste management services, energy distribution and telecommunications). The second is the application layer that enables these infrastructures to be managed and operated. These two levels and the elements that comprise them are not separate entities but closely interconnected systems. Now, with the advent of the Internet of Things (IoT), devices are able to communicate with each other. This enables us to optimise the functioning of global solutions, but it also requires us to make sure that the solutions developed are secure and reliable, not just in the laboratory but under real-life conditions.

TESTBEDS

With this in mind, Switzerland's cleantech ecosystem (see page 20-21) has developed a whole series of large-scale testbeds to test innovations in context. There is a range of testbeds covering major fields such as energy (GridLab, Smartlab, Energy Living Lab), construction materials and buildings (the NEST platform – see page 62, iHome Lab), mobility (Swiss innovation Lab, Mobility Lab, the MOVE platform) and emerging sectors such as connected agriculture. In addition, there are laboratories applying a more interdisciplinary approach, carrying out research in smart cities (Smart city Lab, Swiss Innovation Lab) and business models for digital transformation (Bosch IoT Lab), water and resource management (BlueArk Innovation Hub), social responsibility and sustainable funding (B Lab Switzerland), and other fields.

These laboratories are vital parts of the ecosystem, essential for testing the different technologies on their own and in combination with others, under real-life conditions and on an industrial scale, enabling us to accelerate their deployment.

PV PANELS, THE CONSTRUCTION ELEMENTS OF THE FUTURE

The products and services developed in Switzerland show just how diverse the country's cleantech solutions are. One very prominent characteristic of these solutions is that they often have a number of different applications. Photovoltaic panels, for example, can be used as construction elements in their own right, giving them additional functions. They can help insulate the building (BIPVs) or keep the roof watertight (PV tiles).

The top-of-the-range solar tiles marketed by 3S Solar Plus (Thun, Canton of Bern) can be incorporated into both building renovations and newbuilds. They have, for example, been installed on the Umwelt Arena just outside Zurich and on the Monte Rosa Hut, a mountain hut located at 2883 m.a.s.l, not far from the legendary Matterhorn. The Monte Rosa Hut is almost fully energy-self-sufficient and recycles its wastewater. It is also used by the Swiss Federal Institute of Technology in Zurich for energy and building technology research.



© Umwelt Arena Schweiz

100% energy-self-sufficient apartment building in Brütten

In the energy transition, building envelope design and insulation play a decisive role. Here too, innovation has a part to play, in the new-generation photovoltaic panels. Using technology developed by the Swiss Center for Electronics and Microtechnology (CSEM) and marketed by Solaxess (Marin-Epagnier, Canton of Neuchâtel), solar panels now come in different colours, in particular white, enabling them to be incorporated into façades and roofs. It is even possible to print designs and artwork on these panels so that they can be used as decorative elements.

iWin (Manno, Canton of Ticino) is developing innovative windows with photovoltaic blinds integrated inside insulating glazing units, while Flisom (Niederhasli, Canton of Zurich) has started marketing an ultra-thin flexible solar panel ideal for building envelopes and for use in vehicles such as trucks and airships of the future (see page 97).

BUILDINGS – THE POWER PLANTS OF THE FUTURE

Buildings too are starting to be used to generate power, like the 100% energy-self-sufficient apartment building constructed in Brütten (Canton of Zurich), the brainchild of the property developer Walter Schmid. Assuming an average energy consumption of a four-person family home, including hot water, this pioneering project proves that the concept of the 2000-watt society is achievable using today's technology. To achieve energy-self-sufficiency, excess photovoltaic electricity generated by the building is stored in the form of hydrogen.

When it comes to housing, the concept of self-consumption communities is starting to take off. This forward-looking approach pools the generation and consumption of energy between several buildings. It does however require applications to manage and monitor the building's energy system closely to provide the community with information and ensure each tenant is billed for their own energy usage.

Besides buildings, industrial infrastructure is also being turned into power plants. For example, dhp Technology (Zizers, Canton of Graubünden – see page 98) has developed a folding solar roof that can be used just about anywhere and is particularly suited to car parks and sedimentation tanks of sewage works.



SOFTWARE PLATFORMS

Managing these new buildings requires a separate system of controls. Building automation is on the rise, and this requires management platforms to enable communication between the different items of technical equipment (PV installations, batteries, heat pumps, etc.) in order to control them and exploit their potential to the full. If its use is to be optimised, this equipment must be interfaced with the building's home automation devices (blinds, lights, etc.).

Digital solutions for this are already very much in use, like the home automation applications from eSMART (Renens, Canton of Vaud) and smart-me (Risch, Canton of Zug) (see page 97). Secure remote access-control installations, like the one developed by HOOC (Visp, Canton of Valais), are going to become essential, enabling businesses to be more flexible and reduce their maintenance costs.

The same applies to water management, where one solution for building management and water distribution infrastructures is marketed by Droople (Mont-sur-Rolle, Canton of Vaud) (see page 97).

WHEN ECODISTRICTS BECOME MICROGRIDS

If buildings are becoming power plants, then urban districts are set to become energy networks, or microgrids. With the increased use of renewable energy sources, which by their nature are intermittent, the way the electricity grid operates today bears little resemblance to the grids designed in the past for a steady, centralised generation source. Electricity grids are coming under increased pressure.

Here too, digital monitoring, simulation and management applications are becoming increasingly important. The products marketed by Adaptricity (Zurich, Canton of Zurich) and DEPsys (Puidoux, Canton of Vaud) provide such solutions, valuable aids to decision-making by grid managers.

STORAGE, AN ESSENTIAL NETWORK COMPONENT

Energy storage is taking on a very important role in ensuring that energy grids remain stable and resilient. The major challenge is finding a way to compensate for the offset between electricity generation and consumption, something that is occurring over increasingly long timescales and which will ultimately become seasonal. With its potential for hydroelectric power generation, Switzerland has considerable expertise in pumped-storage installations, with two recently opened large facilities each generating around 1,000 MW, one at Glarus (Linth Limmern) and the other in Valais, just outside Chamonix (Nant de Drance).

With the growth in urban centres and the new microgrids, local solutions are becoming necessary. The battery manufacturer Leclanché (Yverdon-les-Bains, Canton of Vaud), which has been manufacturing batteries and storage solutions since 1909, has come up with a neat approach that can be replicated in urban centres and on other kinds of sites. In 2019 for example, it supplied 3.2 MWh of lithium-titanate batteries for a power plant on the island of Graciosa in the Azores. This solution has helped Graciosa develop a greener energy supply, making it the first island in the world to have its energy needs supplied by more than 65% renewable energy. In environmental terms, this installation represents an annual saving of two million litres of diesel, the fuel conventionally used in electricity generators. The island's more than 4,000 inhabitants now enjoy a sustainable power supply generated by a 1 MW PV solar power system and a 4.5 MW wind farm. This model has caught on, inspiring forthcoming projects in the Caribbean (45 MWh of batteries for a 35 MW solar farm).

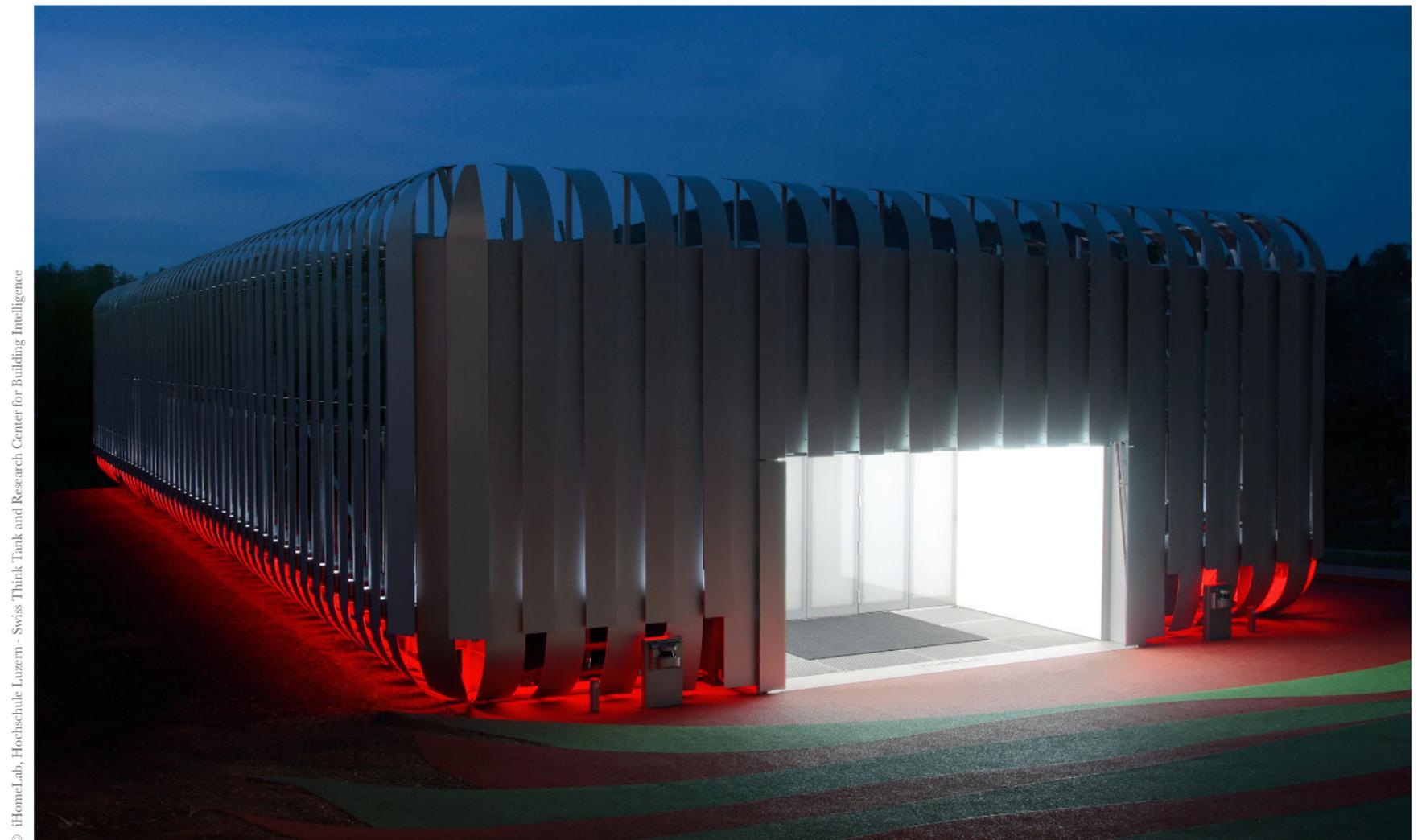
Other models are currently in the pipeline, such as Energy Vault's storage towers (Lugano, Canton of Ticino), plug-and-play power units for off-grid applications from Power-Blox (Frick, Canton of Aargau) and a low-pressure hydrogen storage system using metal hydrides developed by GRZ Technologies (Sion, Canton of Valais).

OILING THE WHEELS...

For microgrids to deliver on their promise and work properly, the magic of electricity requires one particular technological component: the inverter. This device converts the energy generated by a PV solar power system into the form that supplies users. Studer Innotec (Sion, Canton of Valais - see page 100) is the world leader in this field for off-grid locations. This makes it the perfect solution for the self-consumption applications mentioned above.

Lastly, in urban centres, the Internet of Things can play an important role in the energy transition and energy saving. This applies to transport of course, where solutions like the Bestmile fleet management system, FAIRTIQ ticketing or the evpass EV-charging system are implemented, but also to public lighting. For example, Novaccess (Yverdon-les-Bains, Canton of Vaud) provides a way of connecting and remotely controlling infrastructures.

There is a lot still to be done in the field of smart cities and energy systems. At its own level, Switzerland, its research institutes and its businesses are working daily to develop new solutions and new technologies. For a more sustainable world.



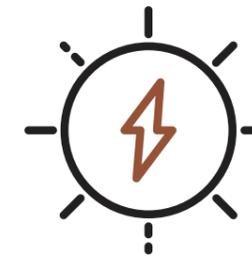
© iHomeLab, Hochschule Luzern - Swiss Think Tank and Research Center for Building Intelligence

Switzerland's Key Facts



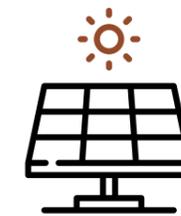
451

Swiss municipalities
have achieved Energy City
certification



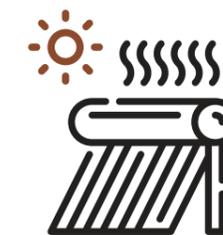
700 companies

around
6,000 jobs
the size of Switzerland's
solar energy industry



750 mill

CHF Photovoltaic annual
turnover in Switzerland



approximately

115 mill

CHF Thermal solar's annual
turnover in Switzerland

INNOVATION PIPELINE

A host of Swiss companies and institutions are currently working on innovations. Here, we focus on a few new products and services with huge potential that are coming onto the market...



© DEPSys

DEPSYS

DEPSys has developed a digital platform called GridEye, capable of designing, operating, monitoring, analysing and automating power distribution grids. GridEye extracts the relevant information and creates value for owners of electricity grids, enabling them to manage their operational transition and to guarantee sustainable electricity.

www.depsys.ch



© eSMART

ESMART

eSMART markets an energy management system for buildings. All of the household appliances are plugged into little modules so that they can be controlled from a touch screen, smartphone or PC. The result? Big energy savings.

www.myesmart.com



© EnergyVault

ENERGY VAULT

EnergyVault builds energy storage towers that work by inertia. This technology was inspired by pumped-storage hydroelectric plants. Instead of containing water, the towers are made up of custom-made composite blocks. These low-cost blocks generate energy when released and have all the advantages of a hydroelectric pumping system but at a much lower initial cost and size.

www.energyvault.com



© Adobe Stock

ADAPTRICITY

Adaptricity develops innovative software that enables network operators to automate repetitive tasks such as connection requests and to carry out network analyses at every voltage. Their software products also evaluate the effects of injection of renewable energy sources into the grid and manage the impact of electric vehicle charging.

www.adaptricity.com

SMART-ME

Smart-me markets a digital solution that uses smart meters to display, analyse and manage the energy data from a building in real time.

www.smart-me.com



© Smart-me

HOOC

HOOC has developed a digital transformation solution for the building industry and industrial automation. Its platform provides easy, ultra-secure remote access, real-time data acquisition, data exchange, and supervision and monitoring of industrial installations, making on-site interventions a thing of the past.

www.hooc.ch



© HOOC

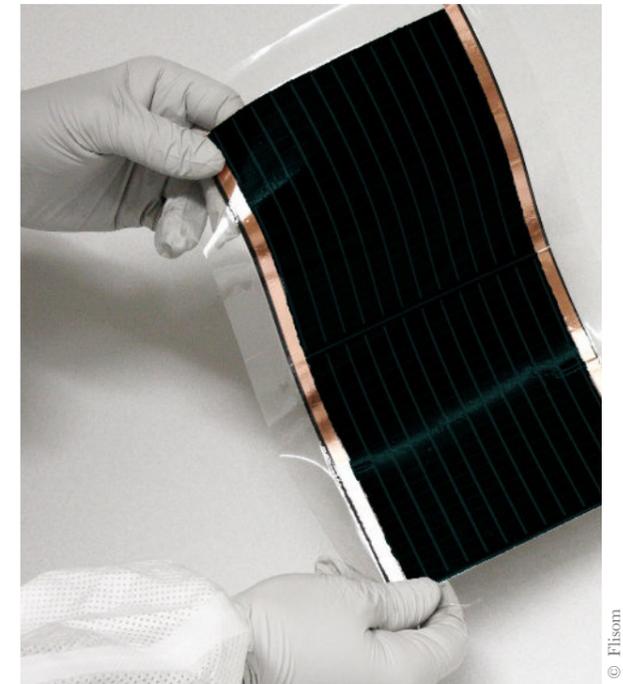
GRZ TECHNOLOGIES

GRZ Technologies has developed an energy storage solution that uses hydrogen and metal hydrides. This has multiple applications, particularly in the seasonal storage of energy generated from renewable sources, but also in mobility and refuelling points for hydrogen-powered vehicles.

www.grz-technologies.com



© GRZ Technologies



© Flisom

FLISOM

Flisom is set to begin industrial manufacture of its flexible photovoltaic modules. This product is based on innovative thin-film solar technology developed in Switzerland. These flexible solar panels have a high energy yield and are ultra-light. They have a host of applications in construction, transport, the aerospace industry and more.

www.flisom.com



© Droople

DROOPLE

Droople has developed a water management platform that uses artificial intelligence and a network of smart sensors placed at each consumption point in a building, such as the toilets, shower, taps and washing machine. These detailed data are very useful to municipalities and utility companies, helping them improve their planning and reduce the residence time of water in reservoirs and the network.

www.droople.ch

Fold-out solar modules



Photovoltaic electricity is most commonly generated using roof panels. But there is considerable additional potential for using other constructions that up to now has been seldom exploited. The solar fold-out roof from dhp technology (in Zizers, Canton of Graubünden) is deployed over treatment tanks in sewage plants to generate renewable energy.

The idea of installing PV modules over the treatment tanks of a wastewater treatment plant (WWTP) might initially raise a few eyebrows, but there is more to it than meets the eye: WWTPs offer vast surface areas that can be used to generate solar power. What's more, the electricity produced can immediately be used locally. "We can re-use the surface area required for the infrastructure installation to generate renewable energy, thereby making a significant contribution to the energy transition," says Gian Andri Diem, co-founder and joint managing director of dhp technology.

The company has developed a support structure that uses cables to enable the photovoltaic modules to fold out over built surfaces and fold up again when required. This makes it possible for large PV solar power systems deployed over WWTP's treatment tanks to generate maximum outputs ranging from 150 to several thousand kilowatts and then to be safely stowed away whenever operational imperatives or bad weather dictate. In Switzerland there are 800 WWTPs, and in the European Union overall there are 80'000. Market surveys have shown that one in three WWTPs are in principle suitable for installing fold-out solar roofs.

And it is this potential that the 20-strong team at dhp technology AG, founded in 2015, wants to tap into.

Encouraged by a successful pilot scheme at the Chur WWTP, five other Swiss sewage treatment plants have committed to installing fold-out solar roofs. In 2019, the EU's Horizon 2020 SME Instrument programme began backing the market introduction of this idea in Europe. This is a major boost for dhp technology, because the company covers the entire value-added chain from planning through to manufacture and installation, and industrialising the necessary processes for export markets is a huge challenge for them.

The idea of fold-out solar roofs dates back to 2012, when Franz Baumgartner, a professor and PV expert at Zurich University of Applied Sciences in Winterthur (ZHAW) and Arthur Buechel from Liechtenstein developed a cable-based system for deploying photovoltaic modules. Gian Andri Diem then joined forces with mechanical engineer Andreas Hügli to take up the idea and develop the technology further to make it market-ready.

CSEM – putting innovation into industry



The mission of the applied technology research organisation Swiss Centre for Electronics and Microtechnology (CSEM) is to support Swiss industry in developing innovations.

A public-private partnership focused on technological innovation, CSEM helps Swiss industry design and develop new devices and products. As the linchpin connecting expertise in technological research with the demands of the market, the Centre makes its laboratories, facilities and expertise available to businesses to help them bring their innovative projects to fruition. Established 35 years ago, CSEM is active mainly in energy infrastructure projects, particularly in the photovoltaic sector, since sustainable development is one of its chief areas of interest. Operating both within Switzerland and internationally, CSEM also promotes the export of Switzerland's talent for industrial innovation.

Solar energy expertise

Collaborating closely with the industry players that draw on its expertise and facilities, CSEM focuses its solar energy work on research in advanced energy efficiency and efforts to make products attractive so that they blend in with their surroundings. When it comes to energy efficiency of solar solutions, the Centre has developed some of the most advanced semiconductors on the market, such as crystalline and multijunction photovoltaic cells. "We worked closely with Solaxess to help the company develop its famous white photovoltaic panels," says Bahaa Roustom, a research scientist and deputy director of marketing and sales development at CSEM. Applied as

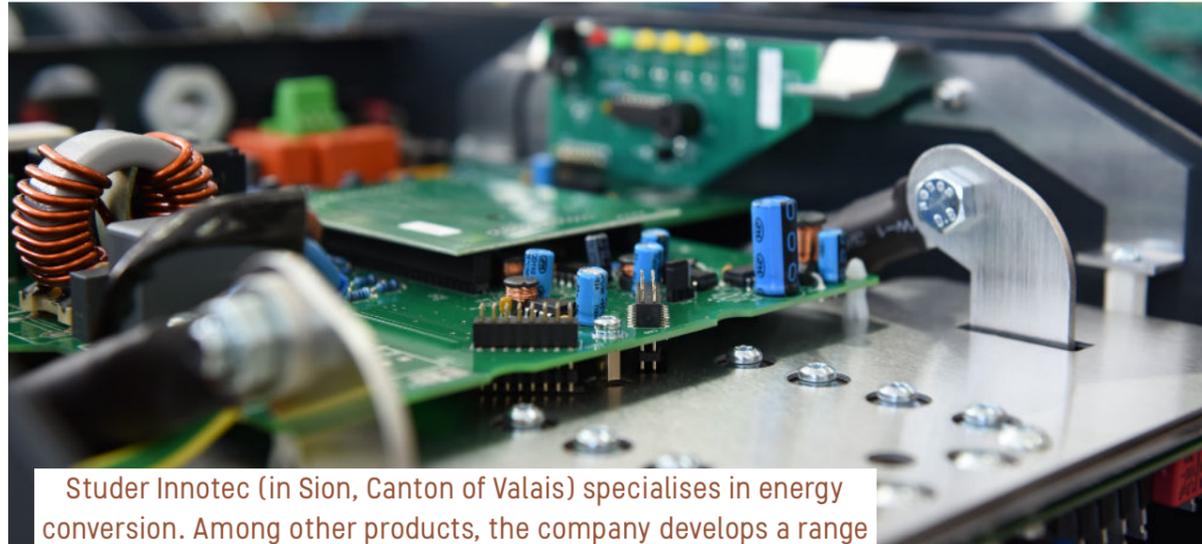
structural components in buildings, they have proved popular with a large number of property developers because this technology makes it possible to incorporate solar infrastructures into building façades, making them usable on a larger scale.

The organisation's latest developments include an ingenious photovoltaic cell that makes use of the ambient light inside a room. This device can be incorporated into connected objects such as watches and cameras, eliminating the need for their own power source.

Energy lab

Another major part of CSEM's remit is energy systems and digitalisation. In this sector, the Centre is working on smart grid technology, looking at incorporating decentralised sustainable energy infrastructures while improving electricity storage solutions and smoothing out the production-consumption curve. In this area, the Centre has mainly been working with Bern University of Applied Sciences (BFH). The resulting synergy has led to the opening of the Energy Storage Research Center (ESReC), which is investigating various storage technologies and developing smart-grid management algorithms.

Studer Innotec, the ultimate mini-grid specialist



Studer Innotec (in Sion, Canton of Valais) specialises in energy conversion. Among other products, the company develops a range of inverters for use mainly on sites without access to an electricity grid. A popular solution on the international mini-grid market.

In places not connected to the electricity grid, mini-grid installations allow flexible current flow management between renewable energy sources – in most cases solar power – and consumers. The key element of these installations is the inverter, Studer Innotec's flagship product, which is part of its range offering various solutions for everything from remote buildings such as mountain huts to high-voltage grids.

Studer Innotec scores over its competitors by producing more robust devices with higher power outputs of up to 72 kVA, ensuring its position as leader on the high-end market, with products made locally in the Canton of Valais and guaranteed for 10 years. The latest additions to the range, the new generation of smart inverters, offer even higher power and greater connectivity. The company has also begun an investment programme to modernise its production lines and entire manufacturing plant.

The success of self-consumption – a shot in the arm for growth

Studer Innotec generates around 15% of its turnover in Switzerland. Exports provide solutions in regions without a reliable electricity grid – mainly in Africa, Asia and India – thus account for 85% of its turnover. “One point 6 billion people in the world do not have access to a public electricity grid, and they never will have,” says

CEO Loïc Viret. Now that they have obtained UL (Underwriters Laboratories) certification, Studer Innotec's inverters will soon be able to access the North American market. These inverters have proved their worth in remote areas, but they are also used in onboard systems and emergency power supplies in hospitals and industry for example.

Studer Innotec's potential for growth is vast. Loïc Viret thinks that this is first and foremost down to the big increase in solar power generation buoyed by the success of the self-consumption market, both on- and off-grid, with the second reason being the growth in energy management services. With energy products becoming increasingly complex, the company has set up several technology hubs, mainly in India and South Africa. “Innovation, quality and service are three values essential to us,” concludes Loïc Viret, underlining the investment his company is making in R&D, which accounts for more than 35% of the company's workforce. Constantly striving to innovate, the company works closely with institutes such as the University of Applied Sciences and Arts Western Switzerland (HES-SO).

Studer Innotec
www.studer-innotec.com

Power from a red cube



The company Power-Blox (in Frick, Canton of Aargau) has developed an energy system that provides reliable electricity in areas without an effective power supply and in disaster rescue situations. The red-cased power cubes can easily be connected to one another to form simple power supply networks.

The new system from Power-Blox is the PBX200, usually known simply as the “Power-Blox”. An integrated inverter means the Power-Blox is not limited to supplying direct current like a battery, but can also supply alternating current. The patented swarm technology allows for the uncomplicated connection of several Power-Blox units via cables to form a supply network, with the capability of scaling up as required. This means that electricity can be supplied not only to individual appliances such as TVs or fridges, but also to larger installations such as field hospitals or even whole villages.

The modular power supply units are used in disaster rescue situations and to provide electricity in off-grid rural areas. The Power-Blox concept has been used successfully in more than twelve African countries, as well as remote parts of the southern Pacific island of Vanuatu. In Switzerland, Power-Blox units are used to power radio aerials without access to the electricity grid, and to supply electricity to Alpine huts.

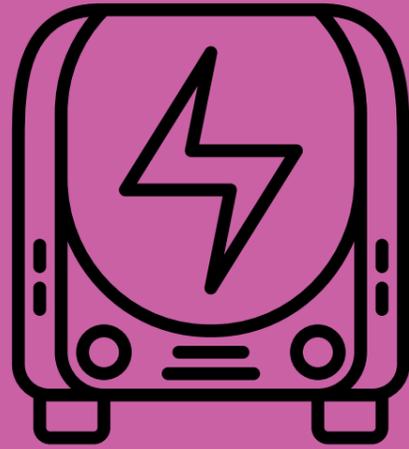
Use abroad is until now been mainly by relief organisations such as the Swiss Agency for Development and Cooperation (SDC), Médecins Sans Frontières, or United Nations aid agencies. The red cubes are sustainable because they are usually charged using renewable energies and, unlike Diesel generators, do not produce noise or

emissions. They are also economically sustainable: Power-Blox are used, for example, in refugee camps to create small grids that give people a positive outlook on life and put them in a position to stand on their own two feet outside the camps – an ideal way of transforming the original aid into a good investment for all parties.

Power-Blox AG was founded in 2015 and has 7 paid employees. The company has supplied more than 1600 of its PBX200 units to customers worldwide. CEO Beat Lehmann no longer refers to his company as a start-up; he prefers to talk of a “scale-up” with a huge potential for growth. “In the seven countries where we currently have projects – Angola, Laos, Mali, Rwanda, Tanzania, Mozambique and Vanuatu – we expect demand for some 1.7 million Power-Blox units in the next five years.”

Power-Blox
www.power-blox.com

Transport & mobility



TRANSPORT & MOBILITY

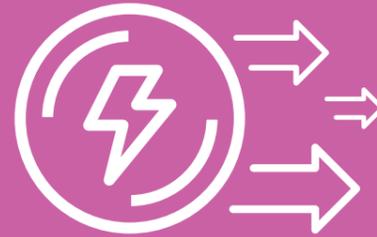
In Switzerland in 2017, 36% of final energy consumption was attributed to mobility¹. As in most western countries, this makes transport the biggest energy consumer, ahead of households and industry. What's more, all fossil fuel powered vehicles, whether used for ground, air or waterway transport, emit fine particulates and nitrogen oxides into the atmosphere. In 2016, vehicles accounted for 38% of Switzerland's CO₂ emissions² and also caused congestion in urban areas and along major communication routes. This state of affairs is forcing Switzerland to reinvent itself and develop innovative solutions, coming up with efficient, clean and quiet ways to get around. To achieve that, mobility must make the most of the technology available and consume fewer financial and natural resources, while being as useful as possible to society.

¹Panorama 2019, Swiss Federal Statistical Office

²Mobility and transport, 2018 Statistics Report, Federal Office for the Environment

In 2020, the development of mobility is dictated by three main trends:

THE ENERGY TRANSITION, WHICH IS TARGETING MORE ENERGY-EFFICIENT CONSUMPTION WHILE WORKING TOWARDS ZERO RELIANCE ON FOSSIL FUELS



A CHANGE IN SOCIETY, WHICH NOW ADVOCATES A PAY-PER-USE CONSUMPTION MODEL



THE USE OF IMMEDIATE AND ON-DEMAND SERVICES MADE POSSIBLE BY THE SPREAD OF DIGITAL APPS AND TECHNOLOGIES (DRIVERLESS CARS, CAR SHARING, ETC.).

These trends feed through to the concepts underlying the management of transport networks and communication routes. They are already having an impact on the ground in the part they play in the new types of vehicles being developed, particularly electric ones. In turn, these new types of vehicles require a dedicated infrastructure (charging points, payment services, etc.), which itself requires managing (to ensure balancing, geographical spread, etc.). The evolution of the business models of transport companies and local authorities is inevitable, as they will be need to incorporate new digital technologies.

This transition from an ownership economy to a sharing economy implies profound changes in mobility. The choices now available are much broader than fifteen years ago. Natural gas, hybrid, electric and much more recently hydrogen vehicles are now on the scene. Multimodal journeys have become commonplace and online ticketing, backed up by a whole battery of services, like the mobile app from FAIRTIQ (Bern, Canton of Bern – see page 121), is today a commodity that the consumer takes for granted. This transition is also reshaping the concepts of mobility in urban areas and municipal territories. Our search for solutions to replace fossil fuels and individual car ownership or single occupancy car use it is becoming more important to embrace efficient multimodal transportation.

Consequently, this global mobility revolution is having a far-reaching impact on the changing structure of the industrial sector. Switzerland may today have a reputation for setting records in its applications and use of mobility (see infographic on page 106-107), but it is certainly not regarded as a major player in the motor industry. This is despite a large number of subcontractors working in the industry, mainly thanks to the country's know-how and expertise in machining and micromechanics. These areas of expertise have been brought together under different umbrella organisations such as the Groupement suisse de l'industrie mécanique (www.gim-ch.ch), Swissmem (www.swissmem.ch) and Micronarc (www.micronarc.ch).

In this mobility revolution, combined with the digital technology boom, Switzerland is becoming a nation that is very much pulling its weight in the development of the sector in areas such as autonomous vehicle management systems, aerial mobility (electric aircraft and drone taxis) and mobile services.

Facts and figures about mobility in Switzerland

Switzerland can rely on efficient public transport and modern infrastructures, despite the alpine terrain for which it is famous covering much of the country. Because of the mountains - with 48 peaks over 4000 metres high around the country - the Swiss have always had to come up with ingenious ways of getting around safely and efficiently. This is one of the reasons why Switzerland holds a host of mobility and transport records.

ENERGY CONSUMPTION

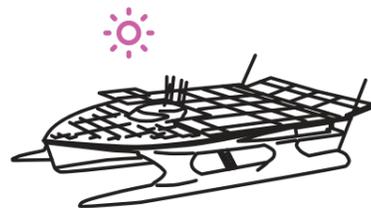


4.1 billion kWh per year

The energy consumption of the country's public transport companies is **4.1 billion kWh per year**, roughly equivalent to the consumption of a million households.

RACE FOR WATER

Today sailing under the flag of the Race for Water Foundation (see cover), in 2012 the catamaran Planet Solar completed the **first solar-powered circumnavigation of the globe** of any mode of transport.

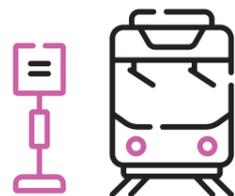


SOLAR IMPULSE

With the solar-powered aircraft **Solar Impulse**, piloted by Bertrand Piccard and André Borschberg, Switzerland holds eight world records, including for the first solar-powered night flight, the first intercontinental flight and the first crossing of the USA. In July 2016, Solar Impulse completed the first aerial circumnavigation of the globe without using a single drop of fossil fuel.



PUBLIC TRANSPORT NETWORK



24,000 km

Switzerland's public transport network is Europe's densest. Laid end to end, it would stretch halfway round the equator. The network is operated by **250 different transport companies**.

STEEPEST FUNICULAR



110%

World's steepest funicular (110%) is the **Stoos Funicular**, in the Canton of Schwyz.

STEEPEST ROUTE



28%

Europe's steepest postal route is in the Kiental (in the Bernese Oberland). Switzerland's **iconic yellow postbuses**, a common sight in the Swiss mountains, regularly ply this route up and down a 28% gradient.

GOTTHARD BASE TUNNEL



57 km

At 57 kilometres, the Gotthard Base Tunnel, which runs between Erstfeld and Bodio, is **the longest railway tunnel in the world**. It was opened in June 2016, 134 years after the excavation of the first Gotthard Tunnel, which became famous as the country's most ambitious project in the 19th century.

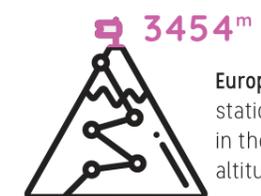
TRAVEL BY TRAIN

on average **71 times**



In Europe, Switzerland is the leading country in terms of travel by train. The Swiss take the train on average 71 times a year, travelling 2,398 kilometres by rail, according to the most recent figures from the EU's statistical office Eurostat. **The Swiss remain the biggest rail users in the world.**

HIGHEST RAILWAY STATION

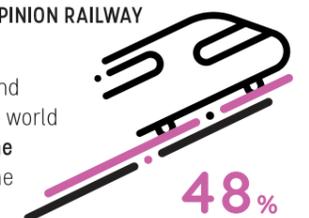


3454 m

Europe's highest railway station is on the Jungfrauoch, in the Canton of Bern, at an altitude of 3454 metres.

STEEPEST RACK AND PINION RAILWAY

The steepest rack and pinion railway in the world (48% gradient) is the **Pilatus Railway** in the Canton of Lucerne.



48%

THE KEY AREAS OF MOBILITY IN SWITZERLAND

THE RAIL NETWORK

Switzerland is a shining example of public transport by rail. A dense network, comfortable rolling stock and an attractive offer – including products such as the GA (an annual season ticket) and Half Fare Travelcards – are part of the reason why the Swiss love to travel by train and why demand continues to grow.

Since the beginning of the 1980s, rail passenger traffic has more than doubled, with freight traffic increasing by 40%. The Swiss Confederation expects this trend to continue. Despite major engineering work, the Swiss railway network will soon be operating once again at the limit of its capacity, with several route sections and stations being affected. The Confederation is therefore planning to invest heavily in the railways up to 2035, with no fewer than 200 projects in the pipeline. The key to running an efficient network inevitably lies in a long-term vision and investment strategy.

When it comes to goods transport, the number of trucks crossing the Alps continues to fall, with the railways taking up the slack. The market share of rail freight reached 70.5% in 2016, demonstrating that the measures introduced to shift goods traffic from road to rail (piggybacking) are working in practice. This concept marketed by Hupac Intermodal (Chiasso, Canton of Ticino), is catching on, with the future Brenner Base Tunnel between Austria and Italy now on the cards (currently under construction).



Switzerland grew up around its railways, to such an extent that today, rail transport is part of the country's DNA. Given that fact, it is hardly surprising that the Swiss are at the cutting edge of innovation when it comes to introducing new technologies with a significant digital element, such as automatic couplers on SBB Cargo freight wagons. A vital step towards achieving partial automation of the last kilometre of rail operation, in which SBB Cargo is leading the way in Europe.

This pioneering spirit is apparent in other innovations, such as the traction transformers developed by ABB Sécheron (Satigny, Canton of Geneva). When it comes to rolling stock, Stadler Rail (Bussnang, Canton of Thurgau) has sold its first FLIRT H2 hydrogen-propulsion train in the United States, and Leclanché (Yverdon-les-Bains, Canton of Vaud) has entered into a partnership with the Alstom-Bombardier group to hybridise diesel locomotives. This system will reduce or even eliminate the use of diesel engines on non-electrified sections of line, thereby reducing greenhouse gas emissions.



ELECTRIC AND URBAN VEHICLES

Road traffic is one of the biggest consumers of fossil fuels. Switzerland's electric mobility roadmap targets an increase in the share of 'rechargeable' vehicles to 15% by 2022. Alternative propulsion technologies reduce energy consumption and CO₂ emissions and increase the proportion of energy from renewable sources. According to a study by the Paul Scherrer Institute (PSI), battery electric vehicles (BEVs) are currently the best option for a low-emission alternative because they are the most efficient users of electricity from renewable sources. This is likely to still be the case in 2040, and is encouraging growing investment in the new materials sector.

The electrification of mobility must enable us to ditch fossil fuels by switching the source of the electricity powering these electric vehicles to energy generated from renewable sources. And on top of that comes the challenge of providing an infrastructure capable of recharging every type of electric car easily, quickly and safely, in Switzerland and neighbouring countries. The mobility sector is evolving towards a model in which vehicles are becoming secondary to computerised management, which is taking centre stage. In the wake of Tesla's success, countries with no vehicle manufacturing tradition can play a key role in this. This is precisely what is happening in Switzerland, where companies with disruptive design approaches for modular vehicles are emerging to complement conventional subcontractors. These companies have the ability to market small urban vehicles, like the Microlino manufactured by Micro (Küsnacht, Canton of Zurich), a company regarded as one of the pioneers of micromobility and which sparked a worldwide boom in the late 1990s with its invention of the kick scooter (micro scooter), a vehicle designed for the last kilometre. Micro has gone from strength to strength and is already selling its sixth-generation kick scooter, the brand-new Micro Commuter and Explorer e-scooters, which means it now covers the full range of urban-user requirements.



© Microlino



© Stromer

Another of these new innovative urban vehicles worth mentioning is Softcar (Fribourg, Canton of Fribourg – see page 120), a fully recyclable modular electric car. In the same vein, Kyburz (Freienstein, Canton of Zurich – see page 124) is innovating with its electric three-wheelers targeting the last-kilometre postal-services and delivery market. In addition, the Microletta, a three-wheeled electric motorcycle concept developed by Micro, is also coming onto the market.

Speaking of the last mile, the Dolphin – designed in the early 1990s by Michael Kutter from Basel (Canton of Basel) – was one of the first electrically assisted bicycles to reach the market. Since then, electric bike brands such as Flyer and Stromer have also claimed a decent share of the e-bike market, which is growing strongly in towns and cities. Of interest too is the electric cargo-bike sharing network carvelo2go. This innovative service is available in 70 Swiss municipalities and continues to expand.

URBAN PUBLIC TRANSPORT

Swiss transport operators are dynamic and creative (see the infographic on page 106). Not content with setting world records and achieving world firsts, Swiss companies are innovating in public transport too. LightTram is an e-bus developed by HESS (Bellach, Canton of Solothurn) and now in use in Switzerland's major cities. This little-known company was behind the COBUS, of which more than 4,000 have been built since it was launched in 1977 for use around Zurich Airport. It is now used daily in more than 200 airports all over the world. This bus was developed in HESS's production workshops and is today manufactured and distributed by COBUS Industries outside Switzerland.

Another innovation is revolutionising public transport: the TOSA (Trolleybus Optimisation du Système d'Alimentation, or 'optimised-power-supply-system trolleybus'). Developed by various partners including ABB, the system provides a fast charge at each bus stop. One route is currently in operation in the city of Geneva and more are to follow soon.



© eMining AG



© BERNMOBIL - HESS

COMMERCIAL VEHICLES

Switzerland has no large commercial vehicle manufacturers but can boast a great deal of expertise, particularly in battery technology and power electronics. This has resulted in a host of system integrators operating in the market (see infographic on page 118-119).

There is no shortage of Swiss success stories in this field, including System-Alpenluft (Zermatt, Canton of Valais), which markets a waste management system featuring little electric urban utility vehicles designed to collect and compact refuse, used for example in Alpine tourist resorts. In a similar vein, this time for use in lowland municipalities, the electric utilities developed by Designwerk (Winterthur, Canton of Zurich), dubbed Futuricum (see page 123), are used to electrify trucks for all kinds of uses including refuse collection, concrete mixing and haulage. The electric trucks developed for a number of years by E-Force One (Beckenried, Canton of Nidwalden) also offer a solution for electrifying and therefore decarbonising goods transport. Still in the field of commercial vehicles, Stimbo Elektrofahrzeuge (Zermatt, Canton of Valais) manufactures the silent electric vehicles that are a familiar sight in car-free mountain resorts such as Saas-Fee and Zermatt.

The eDumper electric dump truck, designed mainly for use in the mining and quarrying industry, is the largest electric vehicle in the world, weighing in at 45 tonnes empty and 110 tonnes with a full load. This extraordinary truck is the result of a partnership between Bern University of Applied Sciences, Interstate University of Technology Buchs, Swiss Federal Laboratories for Materials Science and Technology (EMPA) and several industrial partners (Kuhn, Komatsu, Lithium Storage and Ciments Vigier). Marketed by eMining (Heimberg, Canton of Bern), each truck represents an annual saving of almost 300 tonnes of CO₂ emissions.

A number of mobility projects involving hydrogen propulsion are also under way, such as the one from H2 Energy (Opfikon, Canton of Zurich). This company has joined forces with the motor manufacturer Hyundai to deliver more than 1,000 hydrogen-powered trucks in Switzerland by 2023. At the same time, the GOH project launched by a consortium of Geneva-based companies (Migros, GreenGT, SIG, LARAG and the Nomads Foundation) is developing a hydrogen-powered 40-tonne truck.

AERIAL VEHICLES

In aerial transport, the generation of aircraft to follow Solar Impulse (which circumnavigated the globe under solar power in 2016) is beginning to emerge, such as the electric aircraft from H55 (Sion, Canton of Valais), which is already operational and being used for pilot training. Meanwhile, the start-up Dufour Aerospace (Visp, Canton of Valais) is working on a vertical take-off and landing (VTOL) aircraft particularly suitable for urban mobility.

© Dufour Aerospace



© Anna Pizzolante

MOBILITY SERVICES

The mobility of the future will demand not just an adequate recharging infrastructure but also a whole range of fleet-assistance and traffic-management services. Switzerland's hotbed of innovation has plenty to offer in this sector, with significant expertise in sensor technology and artificial intelligence (AI).

In the sensors market, WayRay (Zurich, Canton of Zurich) develops driving aids that feature augmented-reality holographic technology. And Fastree3D (Ecublens, Canton of Vaud) is developing smart vision systems. When it comes to innovation, both Swiss and non-Swiss companies can benefit from the expertise provided by the Swiss Center for Electronics and Microtechnology (CSEM), an institute with an international reputation in low-power sensors and other areas too (see page 99).

Artificial intelligence plays a part in mobility in platforms like the one on offer from Bestmile (Lausanne, Canton of Vaud – see page 120), which is designed to optimise fleet management. The company cemented its reputation with a world first: the driverless urban shuttle buses that began operating in 2017 in Sion, Canton of Valais.

The right infrastructure – charging stations, for example – will encourage the more widespread adoption of electric vehicles, but it is essential that this user offering is complemented by service management platforms. Green Motion (Le Mont-sur-Lausanne, Canton of Vaud – see page 122) is a pioneer in this field, with more than 1,600 charging stations already installed in Switzerland. The traffic management systems developed by companies like OrbiWise (Plan-les-Ouates, Canton of Geneva) and Novaccess (Yverdon-les-Bains, Canton of Vaud) provide municipalities with the complementary services they need.

And for users, two platforms offer innovative services: FAIRTIQ (Bern, Canton of Bern – see page 121) offers pay-per-use billing for multimodal journeys, and Mobility CarSharing (Uetendorf, Canton of Bern) has a nationwide carpool out on Swiss roads. And in Mobility CarSharing, Switzerland boasts Europe's largest car-sharing operator, with 2,890 vehicles and 1,480 Mobility stations. This service saves on CO₂ emissions. Lastly, with its Green Class package, Switzerland's main public transport operator Swiss Federal Railways (SBB) enables users to combine public transport with use of a shared electric car that is parked at the station.



© WayRay AG



© Michael Flippo

World firsts

Made in Switzerland



eDUMPER

The largest electric commercial vehicle in the world. The first vehicle to be granted 'Energie Plus' certification and the vehicle with the largest onboard battery (600 kWh).

www.emining.ch



SP80

SP80 is a project with ambitions to build the fastest sailing boat in the world. The plan is to enable this revolutionary kiteboard to reach the landmark speed of 80 knots, the equivalent of more than 148 km/h (92 mph).

<https://sp80.ch>



SMART SHUTTLE

The world's first driverless urban shuttle buses were brought into service by CarPostal and Mobility Lab in Sion (Canton of Valais) in 2016.

www.postauto.ch/fr/projet-smartshuttle



STROMER

In 2014, the Swiss brand Stromer brought onto the market the world's first connected electric bike.

www.stromerbike.com



E-FORCE ONE

In 2013, E-Force One marketed the first mass-produced 18-tonne truck in the world to be powered exclusively by batteries.

www.eforce.ch



LECLANCHÉ

Fitted with batteries made by the Swiss company Leclanché, the largest electric ferry in the world made its first commercial journey in August 2019. This revolutionary boat with a capacity of more than 30 vehicles and around 200 passengers is powered by a 50-tonne battery system with a capacity of 4.3 MWh, the largest ever achieved.

www.leclanche.com



THE BEE

Is the world's first hydrogen-powered truck. Fitted with a 455-fuelcell and operated by the Coop supermarket chain, this vehicle is nicknamed 'The Bee', a reference to the quiet buzzing sound made by its 250kW (340hp) motor.

www.actions-not-words.ch

INNOVATION PIPELINE

A host of Swiss companies and institutions are currently working on innovations. Here, we focus on a few new products and services with huge potential that are coming onto the market.



© nox Communication

SOFTCAR

Softcar is an ultra-light electric urban vehicle built out of biopolymers and composite materials. Fully recyclable and made from only 1,800 parts compared to 40,000 for a conventional vehicle, Softcar is touted as the Swatch of the mobility world.

www.softcar.ch



© CarPostal

BESTMILE

Bestmile has developed a fleet orchestration software platform for mobility customers. Among other things, it is used to control and optimise the management of driverless shuttle buses like the ones introduced in Sion (a world first).

www.bestmile.com

NEXXIOT

Nexxiot, a spin-off of ETH Zurich, develops sensors that provide real-time monitoring of the location and transport conditions of containers. The sensors are self-sufficient, requiring no external power source. This makes them very useful for shipping containers and rail freight wagons that have no power supply.

www.nexxiot.com



E-FORCE ONE

The electric truck developed by the Swiss company E-Force One is extremely quiet and emits zero exhaust gases. E-Force One began operating in 2012, with the aim of opening up electromobility to the haulage industry.

www.eforce.ch



© E-Force One



© fairtiq

FAIRTIQ

FAIRTIQ has invented a new way to travel. The FAIRTIQ mobile app automatically detects which journey the user is making, regardless of any changes in the mode of transport, automatically assigning a good-value smart ticket price.

www.fairtiq.com



© Dufour Aerospace

DUFOUR AEROSPACE

The start-up Dufour Aerospace is developing the aEro 2, an electrically powered VTOL aircraft. With a range of 120 km at 180 km/h, it is perfectly suited to urban aerial transport applications.

<https://dufour.aero>

STROMER

Stromer was founded in 2009, the brainchild of the entrepreneur Thomas Binggeli, who wanted to create a bicycle with an integrated battery. In 2014, the Stromer brand brought onto the market the world's first connected electric bike. The accompanying app can be used to change the settings and lock the bike remotely. Over the years, the brand has continued to innovate.

www.stromer.com



© Stromer

LECLANCHÉ

The largest electric ferry in the world completed its maiden voyage in Denmark in August 2019. The ferry's propulsion system is powered by batteries manufactured by the Swiss company Leclanché, one of the world's leading energy storage companies. It has a range of 41 kilometres, seven times that of conventional electric ferries, and its battery recharges in around thirty minutes.

www.leclanche.ch



© Leclanché

Green Motion: electrifying mobility



The electric vehicle charging solutions company Green Motion (in Le-Mont-sur-Lausanne, Canton of Vaud) has set out to conquer the planet... and will soon be taking to the skies too!

Founded in 2009, Green Motion designs and manufactures everything to do with electric vehicle charging points, from domestic installations to public charging stations. It has also developed a software platform designed to manage charging networks which features a charge invoicing system. These two offers are complementary but are also available separately, giving Green Motion two ways in to the market. “Although we do prefer to sell the whole solution as one,” says CEO François Randin.

Green Motion began in Switzerland, but the company received a big boost in 2016 after signing an exclusive licensing agreement for its technology in China. And since 2019 the technology has been used to operate networks in India and Israel too. Green Motion has now set its sights on the American market. Having recently been granted UL (Underwriters Laboratories) certification, its products now meet the standards applicable in the USA and Canada. Standards which essentially amount to protectionism according to the CEO, who says that from a technical point of view its charging points are already compatible with the connection standards of every motor manufacturer.

Little competition

There is therefore effectively nothing now standing in the way of Green Motion expanding into North America, and the company is a frequent exhibitor at Consumer

Electronics Show (CES) in Las Vegas, where it has been showcasing its research into charging stations for electric aircraft. “If you want to arrive on time you have to leave early,” says François Randin, who founded Green Motion at a time when there were fewer than 50 electric vehicles in the whole of Switzerland. “The potential is huge, particularly for flying-school aircraft and air taxis,” he adds. Closely involved with the Swiss SolarStratos and H55 projects, Green Motion is also positioning itself as a player in defining technical standards for electric aviation.

The company has come a long way since 2009. Green Motion’s strengths? Few serious competitors, a long-term vision and highly localised production facilities enabling it to tailor its charging point components to each market. Last but not least... charging points which – with a loss of less than 4% – boast the best power conversion rate in the world.

Green Motion
www.greenmotion.ch

Futuricum has no truck with pollution



In addition to batteries and chargers, the Swiss company Designwerk makes electric trucks. It also designs and manufactures auxiliary power units tailored to customers’ requirements.

No surprise, then, that in 2020 Designwerk was awarded the Watt d’Or by the Swiss Federal Office of Energy, a prize that recognises excellence in energy efficiency, for its Futuricum Project 26E vehicle. Based in Winterthur, north-east of Zurich, Designwerk has been going for more than 10 years. The company specialises in electric mobility, developing and manufacturing innovative batteries, chargers and vehicles. Today it employs a workforce of 65 and has split into two separate entities: Designwerk Technologies GmbH, the parent company, which covers research and development, and Designwerk Products AG, responsible for manufacture, sales and maintenance.

“Most European motor manufacturers use our DC chargers. Small and medium-sized manufacturers looking to electrify commercial vehicles tend to use our modular battery systems. Lastly, we manufacture 18- to 40-tonne electric trucks under the Futuricum brand,” says Fabian Wyssmann, Designwerk’s marketing director. Recycling, distribution, agricultural logistics – these trucks are capable of anything. And the company does more than simply deliver off-the-shelf vehicles, it adapts them to their intended use and their customers’ requirements, for example electrifying the auxiliary power units that operate compactor skips, cranes and cement mixers. Several Swiss municipalities – including Murten, Neuchâtel, Thun and Lausanne – have purchased the refuse collection model of Designwerk’s truck. Zurich and Basel look set to follow

soon. The company is looking beyond the border too, and has already carried out tests in the Netherlands and Germany.

Four-and-a-half times more fuel-efficient than a diesel vehicle

In comparison to their main competitor, the diesel engine, these vehicles have plenty of advantages. They are extremely quiet, emit zero CO₂ and have fewer moving parts that wear out which means that their reduced maintenance costs offset the higher purchase price. Particularly efficient in stop-start traffic, they are very well suited to city-centre distribution and collection services. In ‘pick up’ mode, a diesel vehicle consumes around 90 litres of fuel per 100 km. By way of comparison, a Futuricum truck uses only 190 kWh of electricity per 100 km, the equivalent of 19.6 litres of diesel. It is therefore more than four-and-a-half times more fuel-efficient. These advantages make up for the restricted range of the vehicles, making long-distance use tricky – a point that Designwerk is working hard at improving by plugging into rapid developments in battery technology.

Futuricum
www.futuricum.com

Electric vehicles made in Switzerland



Martin Kyburz is a pioneer of electrically powered mobility. Nowadays, every child in Switzerland is familiar with his electric tricycles, which are used by Swiss Post as delivery vehicles, and these all-rounders are now taking the Asian market by storm too.

Meanwhile, the Zurich-based inventor is continuing to work on even more ideas for the electric vehicles of tomorrow. In 1991, when Martin Kyburz (an electrical engineer by trade) started a company that manufactured electric scooters for the elderly, electrically powered mobility was still in its infancy. His far-sighted thinking would go on to reap rich rewards: since 2009, KYBURZ has been supplying Swiss Post with three-wheeled delivery vehicles for its entire fleet. They have replaced motorbikes that guzzled up to 18 litres of petrol for every 100 km of stop-and-go driving and had a relatively short service life. The tricycles were the first electric vehicles to go into widespread circulation in Switzerland.

The nippy delivery vehicles have also proved popular in other countries. Produced in Freienstein (Canton of Zurich) by the 160-strong workforce of Kyburz Switzerland, they are used in various European countries and by the Australian and New Zealand postal services, and have also recently been rolled out in Thailand and India. “Even though our vehicles are sometimes a little pricier to buy, our customers choose KYBURZ because we offer a reliable, eco-friendly product that will save them money in the long run,” says Martin Kyburz, who as well as founding the company is also its CEO.

The general public associate KYBURZ with postal delivery vehicles, but the company also offers a lightweight

600 kg electric sports car as well as fleet management software that companies, cities and municipalities can use to manage their vehicle fleets in an energy-efficient and cost-effective way. In the Canton of Valais, all snow-ploughs are fitted with the system, which monitors their current position and provides real-time technical data such as salt use and spread range.

Switzerland doesn't have a reputation as a centre for automotive manufacturing, but the example of KYBURZ shows how Swiss companies can make a name for themselves with innovative ideas for niche transport applications. In future, one such application could be automated delivery vans. KYBURZ developers are currently working on intelligent delivery and pallet robots. The robots are in use on commercial sites, and in Norway have already been unleashed on public roads.

Kyburz

www.kyburz-switzerland.ch



“Currently, the energy industry is Switzerland's biggest greenhouse gas emitter. Education, research and innovation in energy technology are the key to a sustainable future.”

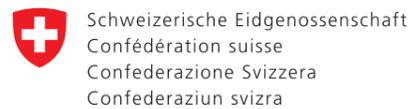
Yasmine Calisesi

Executive Director, Energy Center – EPFL

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SWISS FEDERAL OFFICE OF ENERGY

The Swiss Federal Office of Energy (SFOE) promotes and coordinates Switzerland's energy research and supports the development of new markets for sustainable energy use and supply. Complementary to its regular funding instruments for energy research, pilot and demonstration projects, SFOE initiated in 2020 the new funding program "SWEET". The purpose of SWEET is to accelerate innovations that are crucial to implement Switzerland's Energy Strategy 2050 and achieve the country's climate policy goals.



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Swiss Federal Office of Energy SFOE

www.sfoe.admin.ch



“Thanks to an interconnected innovation community, Switzerland is well on the way towards more environmentally friendly technologies, a key factor for a sustainable energy system.”

Philippe Müller
Head of Cleantech at the
Swiss Federal Office of Energy

CLEANTECHALPS

CleantechAlps, created at the initiative of western Switzerland's Cantons, is the force driving regional and national activities to promote the development of the cleantech sector in Switzerland. It fosters cooperation between the economy, the academy and the public sectors, give stakeholders greater visibility and access to networks. As technology generalist and specialist in cleantech innovation systems, CleantechAlps can put you in touch with the most appropriate contact for your needs.



www.cleantech-alps.com



“The last pandemic has revealed the fragility of a globalized economy. Cleantech are definitely an answer to build a more sustainable and resilient society.”

Eric Plan
General secretary of
CleantechAlps



“Switzerland has a strong research and applied research capability in cleantech which combine with cutting edge SMEs to deliver world class solutions.”

David Avery
Head of Cleantech at Switzerland
Global Enterprise (S-GE)

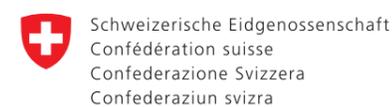
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www.ofev.admin.ch

SWISS FEDERAL OFFICE FOR THE ENVIRONMENT

The mission of the Federal Office for the Environment (FOEN) is to ensure the sustainable use of natural resources including soil, water, air, quietness and forests. It is responsible for the protection against natural hazards, safeguarding the environment and human health against excessive impacts, and conserving biodiversity and landscape quality. It is also responsible for international environmental policy. Environmental policy currently faces a range of important challenges, in particular: climate protection, biodiversity conservation and resource management.



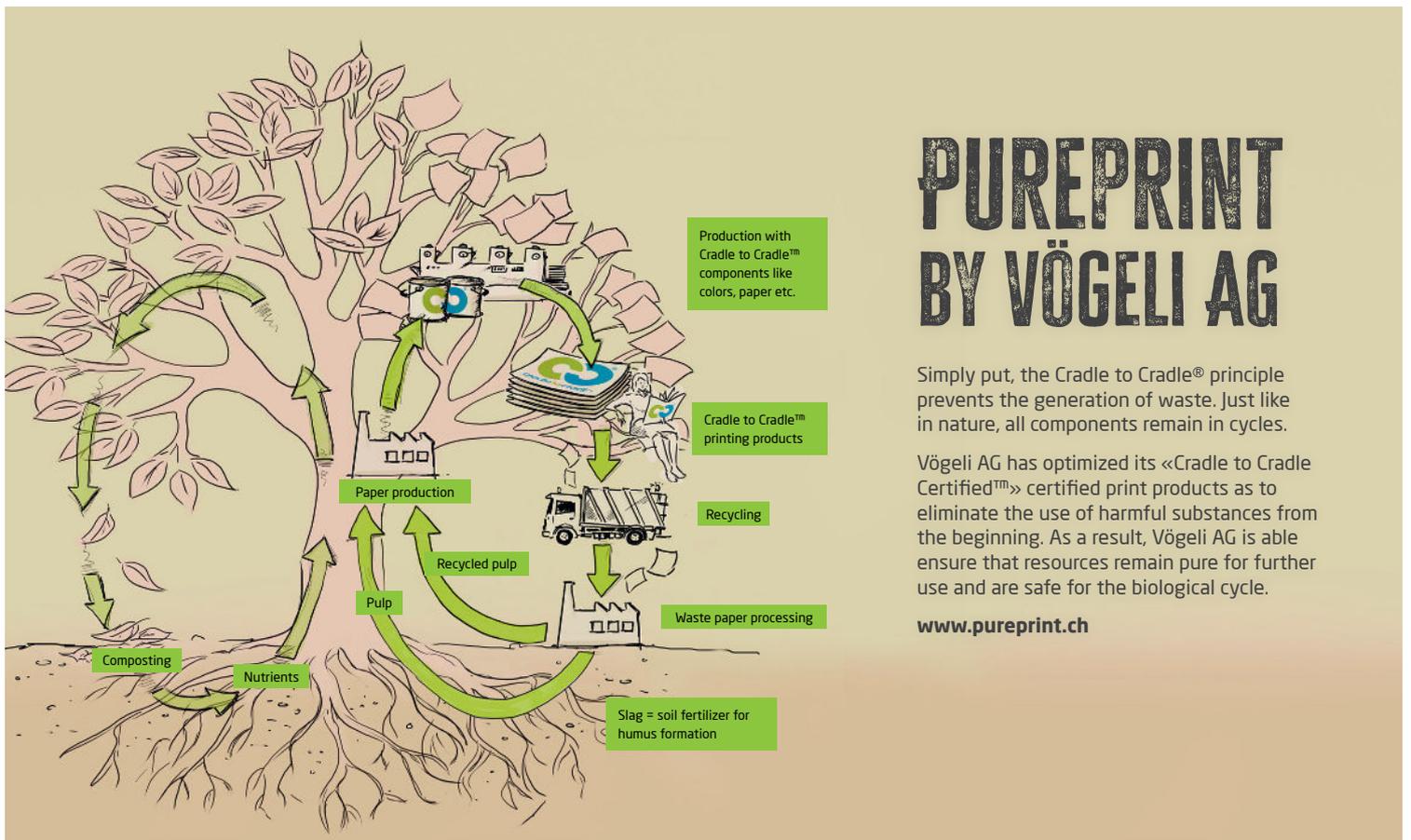
“Cleantech will become one of the big megatrends of the 21st Century and the Federal Office for the Environment will support Swiss companies to play a major role in it.”

Christine Hofmann
Director ad interim of the Federal Office
for the Environment

IMPRESSUM

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