# SWISS CLEANTECH REPORT 2017

The Swiss Cleantech Report (2nd edition) is an initiative of:

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

**Swiss Federal Office of Energy SFOE**

The Swiss Federal Office of Energy (SFOE) is the country's competence centre for issues relating to energy supply and energy use at the Federal Department of the Environment, Transport, Energy and Communications (DETEC).

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**Swiss Federal Office for the Environment FOEN**

The Swiss Federal Office for the Environment (FOEN) is the federal government's competence centre for issues concerning the environment and is part of the Federal Department of the Environment, Transport, Energy and Communications (DETEC).

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The Swiss Federal Institute of Intellectual Property (IPI) is the federal agency for matters concerning intellectual property in Switzerland.

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www.s-ge.com

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CleantechAlps is a platform dedicated to the development of clean technologies in Switzerland, promoting interaction between stakeholders' communities in major economic sectors. Representing technology generalists and specialists in cleantech innovation systems, CleantechAlps can put you in touch with the most appropriate contact for your needs.

www.cleantech-alps.com

# SWITZERLAND IS READY TO TAKE CLEANTECH INNOVATION TO HIGHER LEVELS

Opportunities have to be seized as they arise. At the global level, cleantech will be one of the megatrends in the years to come. The demand for products, processes, goods and services with a smaller environmental footprint will increase significantly. This opens up opportunities for governments, businesses and civil society to invest in the development and use of "clean" products and services. As a result, productivity and prosperity will improve while healthcare costs, the depletion of resources, the volume of waste and levels of pollution will be reduced.

Switzerland has been pioneering environmental innovation for around a century, but of course there are always new challenges to be faced: our railway network – which is one of the densest in the world – was electrified at the beginning of the 20th century. In 2016, we inaugurated the world's longest and deepest railway tunnel: the Gotthard base tunnel is 57.1 kilometres long. It will reduce travel times, improve the energy efficiency of rail transport and contribute to the transfer from road to rail. In the 1970s, Switzerland became aware of the urgent need to protect bodies of water, and thanks to its immense efforts in this regard it has meanwhile succeeded in ensuring that its rivers and lakes once again contain drinking-quality water. Switzerland has also introduced stringent provisions aimed at protecting its forests, preserving biodiversity and reducing $CO_2$ emissions.

Switzerland is ready to take innovation to higher levels and into a broad variety of areas, including buildings, mobility, smart technologies, resilient infrastructure, industry processes, etc. Our country is fully geared to meet the challenges that lie ahead, thanks to its highly qualified experts, world-class universities and research institutions, and numerous small and medium-sized companies, as well as major multinationals, whose business models focus on innovation and international competitiveness. Innovation has to be facilitated through appropriate regulation, training and further education and first-class research and development funding, with a spirit of cooperation among public institutions and businesses.

As a highly developed economy, Switzerland is fully aware of its responsibility to the planet. We have for many years been sharing the international commitments within the framework of Kyoto I and II, have signed the Paris Agreement, were among the first countries to announce national $CO_2$ reduction targets (NDCs), and are helping developing countries make the necessary transition by providing them with financial support. The central components of this policy include our proposed Energy Strategy 2050, our transport policy and our strategy to promote digitisation in Switzerland. All the associated measures share the common goal of promoting energy efficiency and reducing the use of fossil fuels, and thus reducing greenhouse gas emissions.

Innovation is driven by vision. The first flight around the globe by Solar Impulse, the solar aircraft of Swiss pioneers Bertrand Piccard and André Borschberg, is a telling example: we can achieve just about anything if we are truly determined!

As this report testifies, many clean technologies are ready for use today. And the report only presents a selection of the numerous innovations that are already available today or will be in the near future.

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**Doris Leuthard**
*President of the Swiss Confederation in 2017*
*Head of the Federal Department of the Environment, Transport, Energy and Communications (DETEC)*

# A picture-postcard country – but that's not all

Water dam Griessee and the highest-located wind park in Europe, in the Nufenen region

Switzerland is well-known for its "picture-postcard" beauty, with its immaculate white mountain peaks, the crystal-clear waters of its lakes and rivers, its lush green countryside and the purity of the air even in its city centres. Compared with the rest of the world, the quality of Switzerland's ecosystem is uniquely high.

The Swiss are constantly developing solutions using the latest technologies to protect their natural wealth. This desire to innovate and pioneering spirit have helped forge Switzerland's national identity, enabling the country to achieve outstanding performance in areas as diverse as the management and recycling of waste, public transport, energy efficiency and land management. A sustainable approach to using natural resources has long been established.

The aim of this publication is to provide a presentation of the technologies and innovations developed in Switzerland. These include Solar Impulse, which in July 2016 completed a successful round-the-world flight powered by solar energy. Plenty of other projects flow from the Swiss people's creative minds every year, which may not attract as much media attention but nevertheless give Switzerland a well-earned reputation as a nation of clean technologies.

If you like the sound of the range of solutions featured here, you can of course obtain more detailed information about any of them – simply **contact us** to arrange a visit. Read on for a fascinating journey into the world of cleantech!

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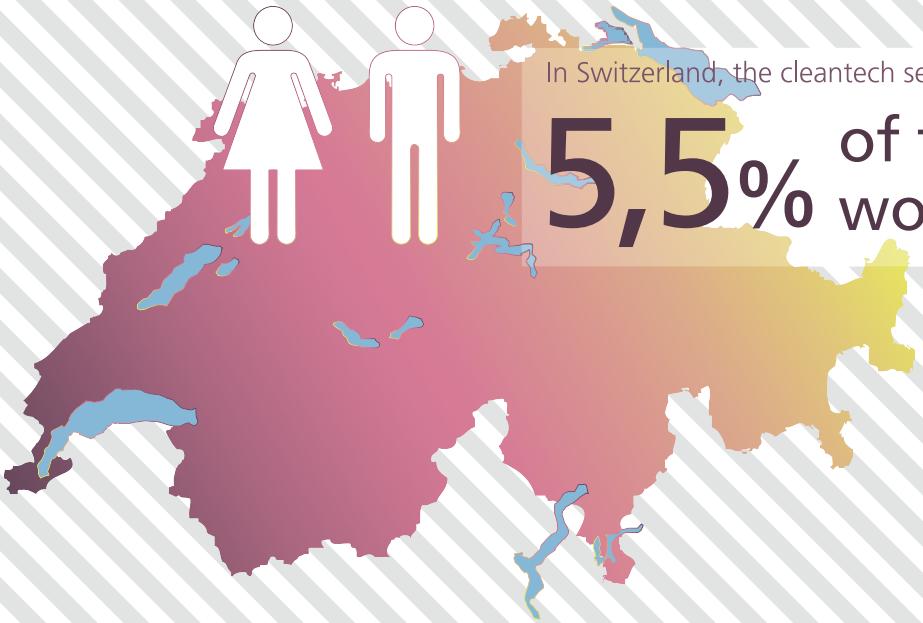
# What is cleantech?

## AN IMPORTANT AND GROWING PILLAR OF THE ECONOMY



In Switzerland, the cleantech sector currently employs...

**5,5%** of the total workforce

about **23** billion euros per annum of gross added value

*4,2%* of GDP

**25%** increase of cleantech jobs over the last 5 years

(Source: EBP 2010/2015)

The term cleantech, sometimes used interchangeably with greentech, sustainable technologies, or environmental technologies, embraces a wide range of innovative products and services that contribute both financial returns and positive environmental impacts and outcomes (definition from the Cleantech Group).

To be more specific, cleantech covers those technologies, products and services that protect the environment by providing for the sustainable utilisation of natural resources and the production of renewable energy. They aim in particular to reduce the consumption of these resources and to conserve the natural ecosystems. New technologies have a fundamental role here. An importance is increasingly also being attached to the role of users and the understanding of their behaviour.

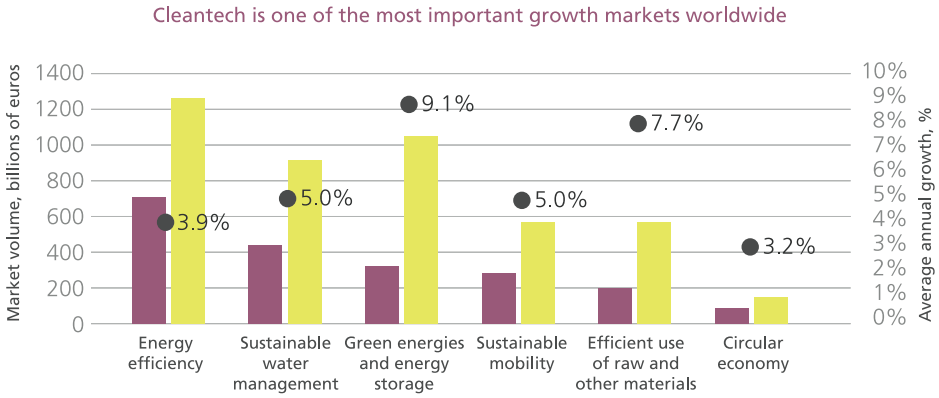



*Figure 01: Global market for the various cleantech areas (Source: R. Berger)*

## MUCH MORE THAN MERE TECHNOLOGY...

The cleantech concept is not only about the simple utilisation of innovative technologies that safeguard natural resources – it also embodies an attitude, reactions and a way of life which inspire individuals and companies in all sectors to act in a way that conserves natural resources. Human activities and economic processes should therefore be rethought to incorporate the principle of the efficient, respectful use of raw materials, energy and water. With cleantech, the world really is entering a new era of sustainable development.

## ...AND ONE OF THE LARGEST GROWTH MARKETS WORLDWIDE

The areas with the greatest global potential are, unsurprisingly, energy storage and the efficient utilisation of raw materials and energy sources (cf. Figure 01, R. Berger). An annual growth of almost 10 per cent is anticipated for energy storage. The global market volumes are expected to triple for storage and practically double for energy efficiency by 2025. Similar trends apply to water management and sustainable mobility.

### FACTS

The majority of cleantech companies in Switzerland are small and medium-sized enterprises (SMEs). Many of them are very well integrated into the global supply chains.

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There are also a number of firms large enough to be listed on stock exchanges, such as ABB Ltd., Burckhardt Compression Holding AG, Huber+Suhner AG or Meyer Burger AG.

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Innovative start-ups such as L.E.S.S or Designergy are spun off every year from top-notch research institutes like ETH and Empa in Zurich and EPFL in Lausanne.

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The estimated public expenditure on supporting cleantech R&D in Switzerland was over 0.5 billion dollars in 2014, additionally the R&D expenditure of Swiss cleantech companies far exceeded the public R&D expenditure.

# Switzerland and cleantech – a love story that goes back to 1882

Innovative, pioneering policies relating to environmental protection have made Switzerland one of the world's leaders in the development of "cleantech" products and services. Based on a desire to protect the ecosystem, Switzerland was the first European country to enact an environmental protection law. The effects of this forward-looking legislation can be seen every day, for example in the quality of water in our springs and rivers.

The capacity of the Swiss for innovation and high-tech manufacturing ensures that the country leads the way with its transport networks, production of electricity from renewable sources, waste processing and recycling of materials, and energy efficiency. Here is a quick history with significant dates that have marked the enduring love story between Switzerland and cleantech.

## INFRASTRUCTURE AND TRANSPORT NETWORKS – IT ALL BEGAN IN 1882

Over the centuries, Switzerland has constantly improved its communications, transport and energy distribution infrastructures. Building its current position step by step, it is now a central interchange hub for Europe. This privileged position is reinforced by the rail network that criss-crosses the land – the densest in the world.
The first Gotthard railway tunnel, which links the north and south of the country beneath the Saint-Gotthard Massif, a mountain range at the heart of Europe, was opened in 1882. This 15-kilometre feat of engineering, which cost numerous human lives, held the record for length for a long time. The record was won back by the new Gotthard base tunnel which was opened on 1 June 2016, extending to almost 60 km.

## AN INNOVATIVE CONCEPT AHEAD OF ITS TIME: PIGGYBACKING

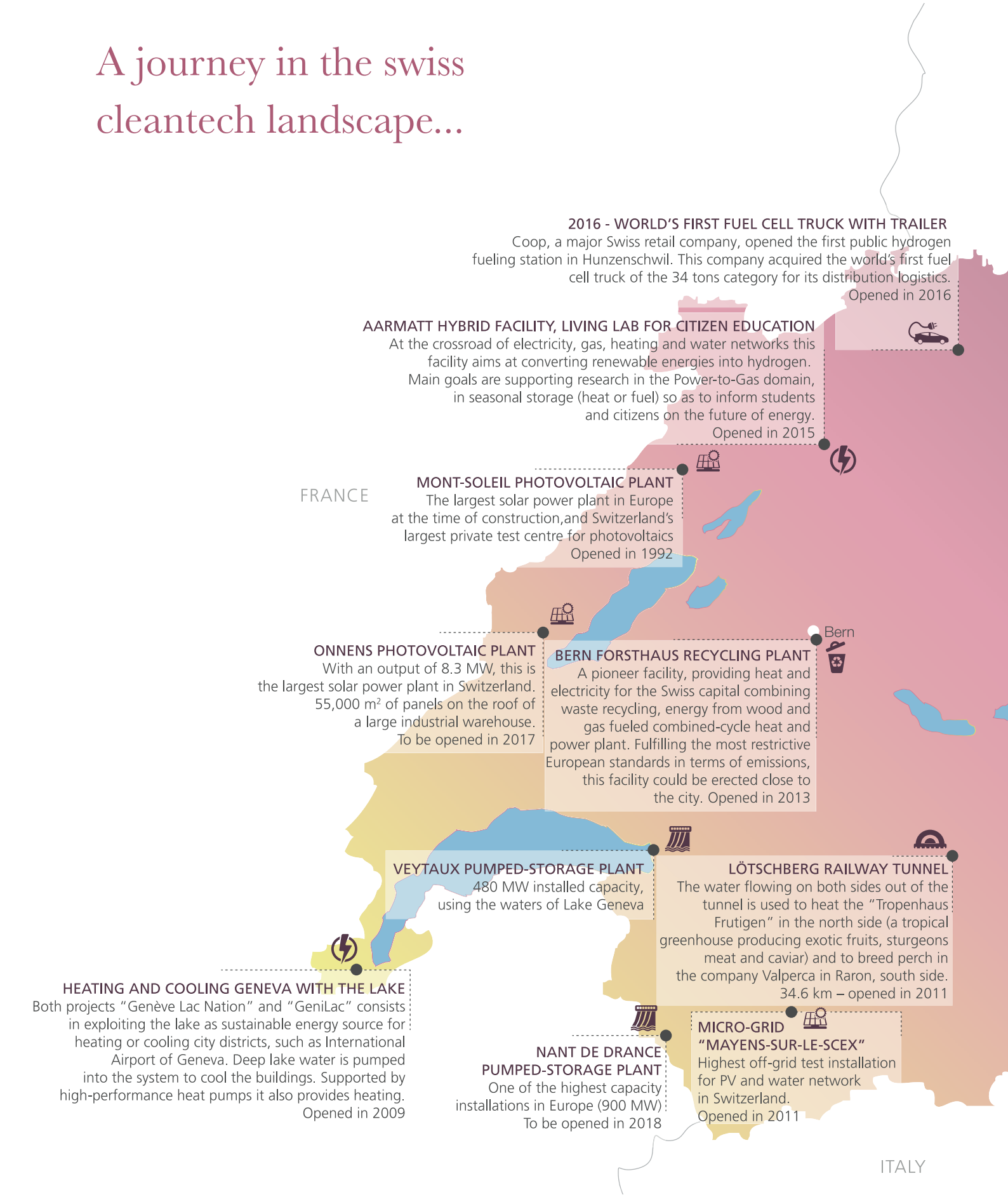
Transferring transportation from road to rail by carrying lorries on trains – the concept known as "piggybacking" – also features among the Swiss priorities and areas of expertise relating to rail transport.
Piggybacking was launched as a visionary concept in the 1960s by Swiss company Hupac and is now seen as a more environmentally friendly mode of goods transport. It helps to reduce greenhouse gas (GHG) emissions, while also decreasing noise pollution and the impact on the landscape. This innovative concept makes a valuable contribution to the long-term reduction of climate change triggers.

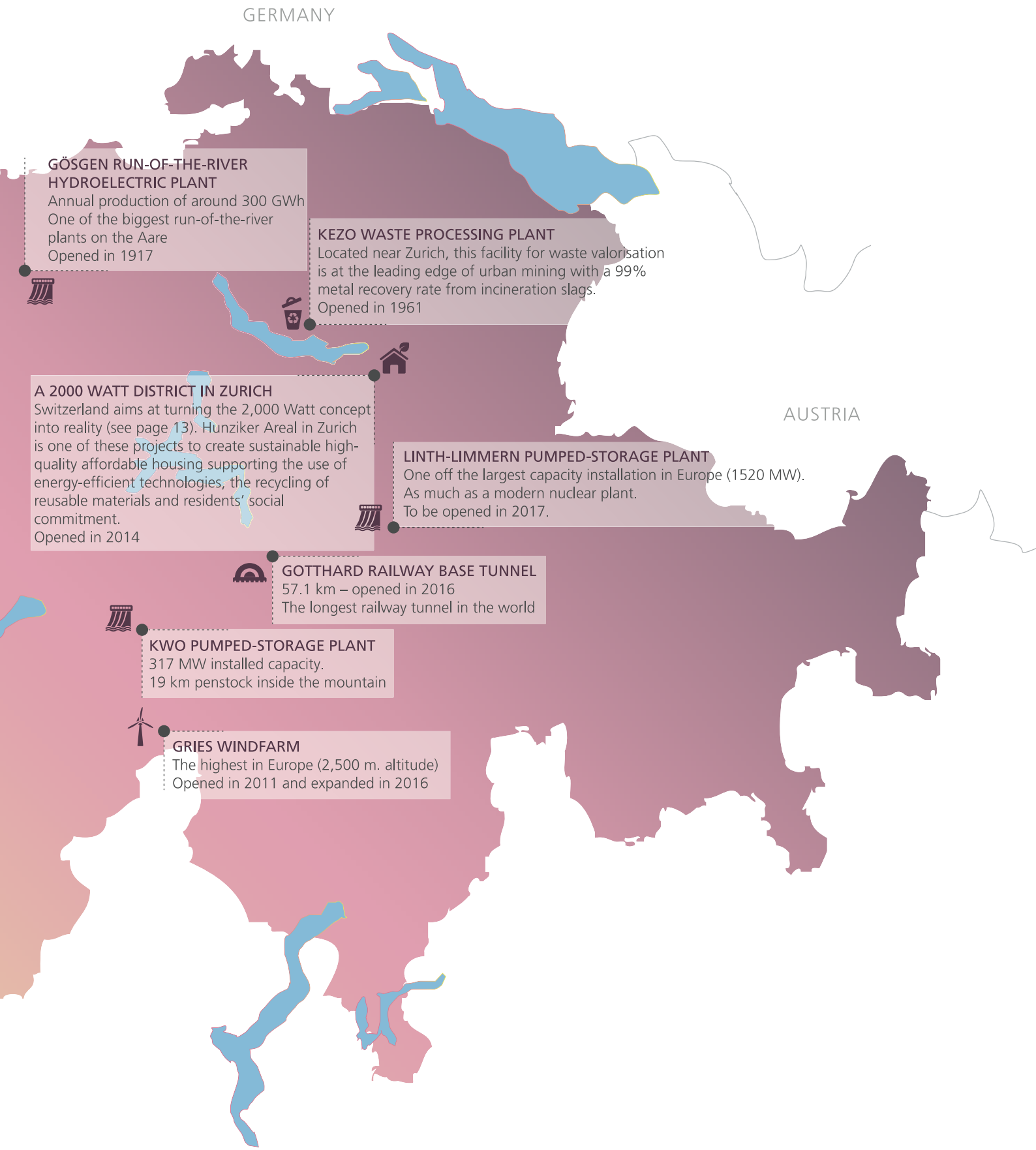
Top notch public transportation and infrastructure: a train goes out of the Gotthard tunnel, the longest of the world.

## CONTINUAL OPTIMISATION OF ENERGY EFFICIENCY

As well as regular renovation of the rolling stock to take account of the latest developments by local manufacturers (ABB, Stadler Rail and Bombardier), Swiss Federal Railways (SBB) optimise the management of their rail network on an ongoing basis, in particular using an innovative software solution that enables the energy consumption of trains to be reduced in real time. The location of the trains on the network is constantly analysed and the drivers are given acceleration and deceleration instructions, thereby optimising the electricity consumption and achieving savings of up to 15%.

# A journey in the swiss cleantech landscape...






# ...from heavy infrastructure to multi-purpose test platforms at the leading edge of innovation


TOSA Bus, developped by ABB: No overhead lines and ultrafast charging times at bus stops pave the way for the next generation of silent, flexible, zero-emissions urban mass transit.

## CITIZENS' MOBILITY

A country without natural energy resources, with the exception of water and biomass, Switzerland has built its prosperity on its inhabitants' brainpower. This is expressed in a wealth of innovative concepts, in particular in the energy and environment sectors. Mobility is one of the areas that benefits from this dynamic. Over the course of recent years, Switzerland has become a leading light in the field of carsharing, with the excellent example of Mobility Carsharing which, according to a study by the Swiss Federal Office of Energy (SFOE), has become one of the largest companies of its kind in Europe. Dating back to 1987, the organisation now has 120,000 members, many of them professionals, sharing 2900 vehicles at 1460 locations spread throughout 500 Swiss towns and cities.

## BACKING RENEWABLE ENERGY

With its reputation as the water tower of Europe, Switzerland began to exploit the potential of hydroelectricity at a very early stage. At the end of the 19th century, between 1869 and 1872, Europe's first concrete gravity dam was constructed at Pérolles, to the south of Fribourg.

Dozens of dams were built between 1950 et 1970, including the Grande Dixence, the tallest gravity dam in the world at a height of 285 metres (935 ft). This shining example was accompanied by a large number of structures of all sizes throughout the country, in particular plants with multiple uses such as harnessing drinking water to drive electricity turbines – all in all, a real showcase for the country's hydroelectric expertise.

More recently, pumped-storage installations – effectively recharging systems that work by storing water – were introduced to further increase productivity and above all to provide a way to adjust the available energy for the European and Mediterranean networks.

The latest of these major structures, Nant de Drance, located on the border between France and Switzerland close to Mont Blanc, is currently under construction. A prime example of how the traditional hydroelectricity sector is constantly reinventing itself, this impressive project, which received the Major Tunnelling Project of the Year award in London in 2014, is a veritable cathedral for modern times, constructed below ground to house the vast machine hall.

The proportion of energy from hydroelectric sources is now approaching 60% (58.4%, FSO 2015) with the potential for more from the optimisation of the installations and the continued development of small-scale hydropower (installations with a capacity of less than 10 MW). However, the proportion of other renewable sources in the Swiss electricity mix is still relatively low (4.45%, FSO 2015) in comparison with its European

The Nant de Drance pumped storage power station: an epic building project.

neighbours. This may come as a surprise in the photovoltaic solar power sector, considering that the research into and manufacturing industry for solar panel production lines is a leading sector in Switzerland.

## ENERGY EFFICIENCY

As has been noted, Switzerland is the source of a wealth of innovative concepts. This is exemplified in the energy sector, by the concept of the 2,000-watt-society, a long-term vision that was first developed by the Swiss Federal Institute of Technology Zurich (ETHZ) back in the 1990s. The idea is that 2,000 watts and one tonne of $CO_2$ per person, per annum should be enough to maintain a comfortable quality of life: ambitious objectives that it is hoped will be attained by the year 2100. At present, the average Swiss citizen consumes approximately 6,000 watts per annum.

This is a huge challenge requiring innovations in all areas of life – social (behaviour), societal (political and legal frameworks and conditions) and technical (technology). It illustrates the Swiss will to prioritise quality over quantity in order to provide an intelligent energy supply system and to involve the country's citizens in the energy transition.

This theoretical concept is put into practice in the context of the Energy Cities programme. More than half of the population live in one of the 400 Swiss towns, cities or municipalities certified as Energy Cities.

### ENERGY CITIES – A LABEL EXPORTED ABROAD

The Energy Cities use energy efficiently, encourage renewable technologies such as hydropower or solar power, and implement environmentally friendly mobility policies. This is the kind of initiative with which Switzerland is equipping itself to face the challenges of tomorrow. The programme, implemented by SwissEnergy, is already being emulated abroad, for example in Chile under the supervision of Ernst Basler & Partner.

## A MARRIAGE BETWEEN ENERGY EFFICIENCY AND RENEWABLE ENERGIES

Pioneer projects, such as Solar Impulse, PlanetSolar and the world's first energy self-sufficient residential complex, established in Brütten (Zurich), act as international ambassadors for Swiss values. The translation of these visionary ideas into actual solutions is made possible by a strong interconnection between the research institutes, with their networks of excellence and expertise, and SMEs.

## DYNAMISM AND CREATIVITY ALSO IN THE FINANCIAL FIELD

Known for its long tradition in financial services, the Swiss cleantech ecosystem still reveal dynamism and creativity in terms of financial issues. Some 30 years ago, private bank Lombard Odier was pionnering the cleantech sector by offering one of the first european sustainable investment funds. Based in Zurich and Toronto, Emerald Technology Ventures, one of the global VC leaders focused on cleantech, launched early 2016 a brand new "ever green fund" providing smart and patient money requested for capital intensive clean technology ventures showing a promising way to go in this sector.

As cleantech is not only reserved for northern or developed countries, access to capital in urban and rural emerging countries is important. Here again, Switzerland played an active role by supporting the new microfinance stream allowing to start (sustainable) micro businesses. A study based on 84 investment vehicles in microfinance (covering 96% of the world financial assets of microfinance investment, around 9.5 billion euros for all economic activities, not only cleantech related ones) reveal that 55% of these assets are managed by Switzerland and the Netherlands ahead of Germany, USA and Luxemburg (Source: Symbiotics, MIV Survey; Key Survey Facts, 2014/2015).

From 2010 onwards, specific initiatives on sustainable or participative financing were developed, such as Swiss Sustainable Finance (SSF) which strengthens the position of Switzerland in the global marketplace by informing, educating and catalyzing growth. In this dynamism, besides crowdfunding, a new type of investment's philosophy and vehicle emerged: the cooperative for sustainable economy. One Creation Cooperative is a company bringing a dedicated instrument to the investors community to support the rapid development of environmental technologies through a global multi-sector approach. This instrument is a way to financially support those companies in the long term, and accompany them in the realization of the wide-array of ecological, climatological, societal objectives of the Sustainable Economy. This instrument is a way to support in the long term the realization of the COP21 objectives. Most recently, the Swiss Impact Enterprise Association acknowledged that the traditional market economy needs a large transformation to cope with the challenges our world faces.

The 3,835 m. Refuge du Goûter on the route of the top of Mont Blanc, is an innovative and environmentally-friendly building, designed by Swiss architects Groupe H and DécaLaage (France), supported by Charpente Concept (Switzerland). An admirable example of international collaboration for high-tech concepts' realisation in extreme conditions.

# Swiss cleantech pioneers and records

## SELF-SUFFICIENT BUILDINGS

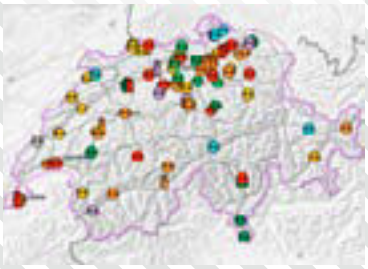
In June 2016, Switzerland introduced the world's first energy self-sufficient residential complex. The building was officially opened in Brütten by Federal Councillor Doris Leuthard. With its energy supplied by solar panels, the building's modern fabric and technical installations, and high level of energy efficiency (production, storage, consumption), mean that it has no need for connection to the external electricity, heating oil or gas networks. "The Brütten residential complex is proof that buildings can be energy self-sufficient without compromising on comfort," Federal Councillor Doris Leuthard said in her speech.

## SOLAR IMPULSE

A pioneering project involving a single-seater electric aircraft powered completely by solar energy. The aircraft benefits from an almost unlimited range, enabling it to reach Abu Dhabi in July 2016 having made its first solar-powered round-the-world flight, breaking record after record.

## FLAGSHIP PROGRAM

With its pilot, demonstration and flagship programs, the Swiss Federal Office of Energy (SFOE) supports the development of innovative clean technologies and solutions, and support companies bringing them onto the market. An interactive map, with all projects, is available here: **www.bfe.admin.ch/cleantech**



## MAIGRAUGE DAM

This installation was the first concrete gravity dam in Europe (built between 1862 and 1872).

## JOSEPH JENNI

Joseph 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 individual family home to have all its energy needs supplied by solar power.

## PLANETSOLAR

With more than 500 m² of solar panels, this is the biggest solar-powered boat in the world. Between September 2010 and May 2012 it completed the first solar-powered around-the-world voyage in the history of humanity, covering 60000 km as it crossed all the planet's oceans powered solely by solar energy.

## RAIL NETWORK

In 1882, the first Gotthard Railway Tunnel was the longest of the world. Now, Switzerland's railaway density ranks third in the world. (source: worldstat.info)

## HYDROELECTRICITY PIONEERS

The Grande-Dixence dam is the highest gravity dam in the world and the one at Mauvoisin is the highest arch dam in Europe. These two structures, erected in 1961 and 1958 respectively, remain to this day evidence of Switzerland's pioneering spirit.

## WASTE WATER

More than 95% of homes in Switzerland are connected to a sewerage network that collects waste water and conducts it to a waste water treatment plant. A renovation programme costing 1.1 billion euros will equip the 100 largest of these with facilities to eliminate micro-pollutants by 2030.

## ENERGY PRODUCTION

97% of Switzerland's electricity production is $CO_2$ neutral (with 55% of this generated from renewable energy sources).

## HEAT PUMPS

Switzerland leads the pack with the greatest number of geothermal probes and heat pumps in the world, giving an average density of one installation every 2 $km^2$ (source: SIG).

## MONTE ROSA HUT

This high-altitude mountain hut was renovated in 2009 to high-tech specifications that put it at the forefront of sustainable development. Known as "the most complex timber structure in Switzerland", the building, at an altitude of almost 3,000 metres, has an aluminium shell and an IT-based energy management system that enables it to be controlled remotely.

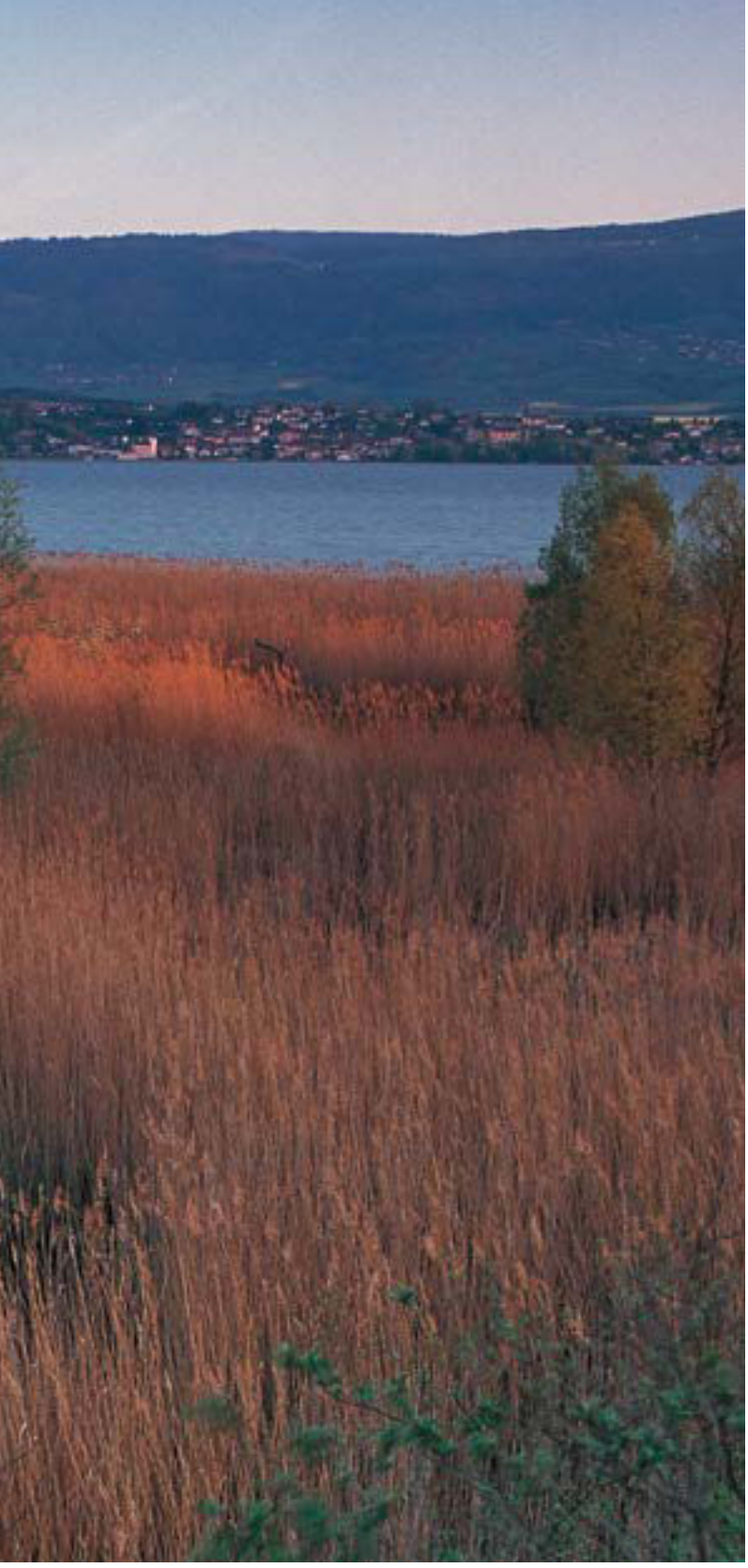
## IMPRESSIVE RECYCLING RATES

With waste recycling (98%), incineration of solid municipal waste (> 90%), aluminium (90%) and paper (97%) recovery rates, Switzerland is the world's leader in recycling and waste reprocessing. The country's extensive expertise in the art of recycling includes glass, aluminium cans, PET bottles, organic waste and electrical and electronic equipment.

## THE FIRST CONNECTED PHOTOVOLTAIC INSTALLATION

It was in Ticino in 1982 that the first PV installation in Europe was connected to the grid. This was the rooftop installation at the University of Applied Sciences and Arts of Southern Switzerland (Supsi) in Lugano. The objective was to use this 10 kW plant to study the safety problems that might arise from connection to a public electricity grid.

# Swiss environmental protection policies



Grande Cariçaie, Neuchâtel

On 25 May 2011, following the Fukushima nuclear disaster, the Federal Council, at the instigation of Doris Leuthard, the head of the Federal Department of the Environment, Transport, Energy and Communications (DETEC), decided that Switzerland should commence a progressive withdrawal from nuclear energy. This choice, confirmed by the Federal Parliament, marked the departure point of a new Swiss energy policy, called "Energy Strategy 2050". According to this, the five nuclear power plants are to be decommissioned at the end of their useful lives and will not be replaced by new ones. Hand in hand with this strategy goes the Cleantech Masterplan, a political instrument to strengthen the development of cleantech products and services in Switzerland.

### THE CLEANTECH MASTERPLAN FOR SWITZERLAND

Published in 2011, the Cleantech Masterplan for Switzerland forms the framework that enables the Swiss Federal Council to undertake the necessary activities in the fields of resource efficiency and renewable energy. These activities, implemented between 2011 and 2014, support the development of cleantech products and services in collaboration with Swiss industry. From 2016 onward, these framework conditions will be ensured by a cleantech coordination group within the administration.

The energy transition triggered by these developments is one of the greatest energy challenges for Switzerland. It is a formidable catalyst for developing new solutions and processes, and for boosting the deployment of renewable energies.

## TOWARDS A GREEN ECONOMY

Switzerland is turning towards a greener economy, with the desire to promote a more efficient use of resources while reinforcing economic performance and general well-being. The transition towards a green economy will be a major preoccupation for both Switzerland and the international community over the coming decades. It involves, on the one hand, providing companies with incentives to continue to innovate, producing state-of-the-art, resource-saving technologies they can market globally, and on the other hand, reducing consumption to more ecologically sustainable levels.

In order to succeed in this transition, Switzerland must be able to rely on framework conditions that favour innovation, supported by a strong voluntary commitment by the economy and society. An action plan, adopted by the Federal Council in March 2013, detailed 27 measures aimed at making progress towards a green economy in areas relating to consumption and production, waste and raw materials. A second set of measures has since been added, adopted by the Federal Council in a report on the Green Economy in 2016.

Switzerland aims to use this policy to reduce its ecological footprint generally in an international context, and to demonstrate specific courses of action to countries and organisations wishing to draw up similar roadmaps in this field. These political objectives for the protection of the environment have been given expression in the recent climate conferences in Paris (COP21) and Marrakesh (COP22). Switzerland played a prominent role at these global assemblies, proposing some concrete solutions.

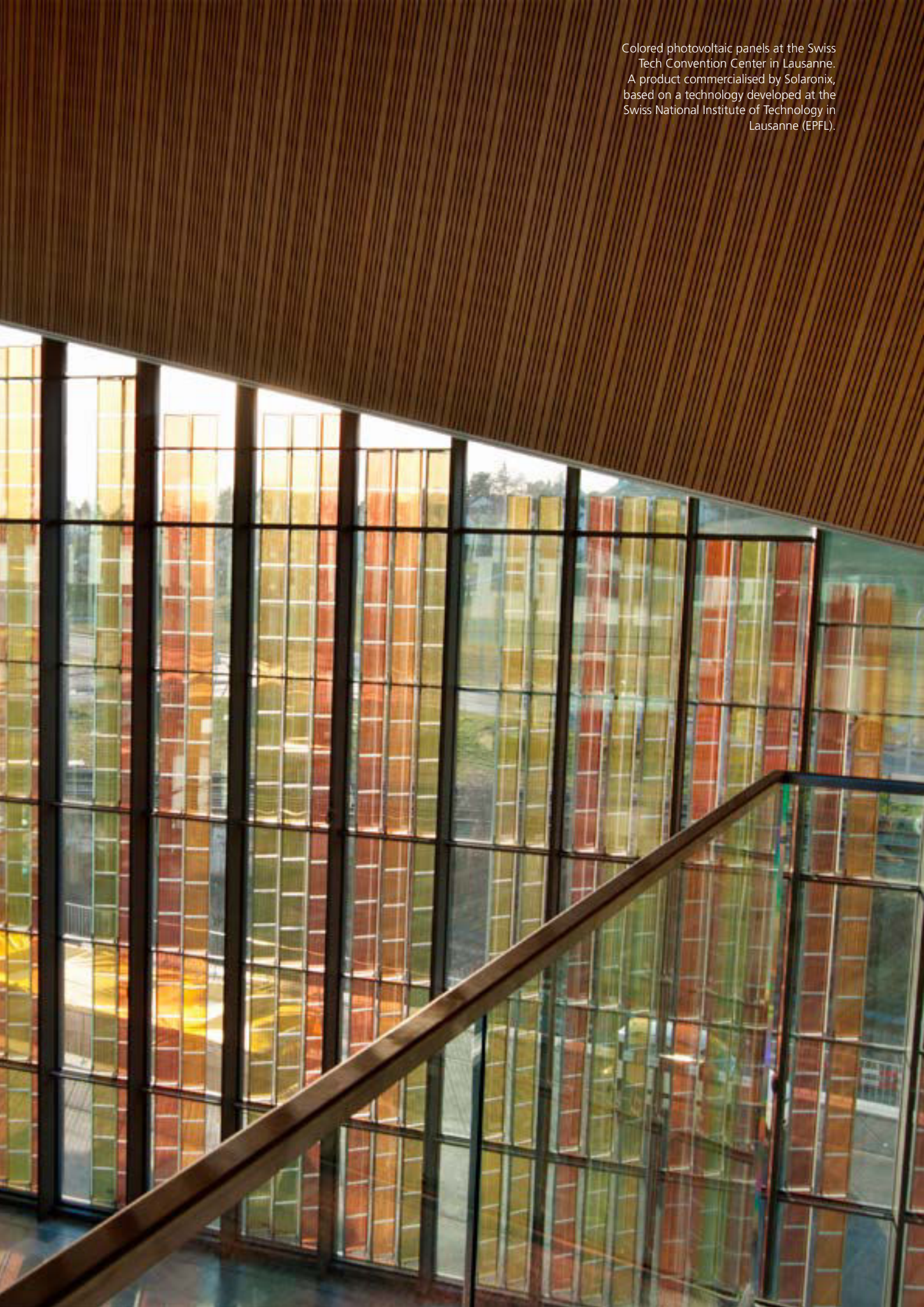
### COP21 IN PARIS: WHAT NOW?

The Swiss Confederation will contribute 100 million dollars to the climate fund. It will also provide financial support of almost 300 million dollars per annum for measures in developing countries.

### *THE GREEN ECONOMY*

The new report on the Green Economy defines 23 measures for the period 2016-2019 in the following nine priority areas:

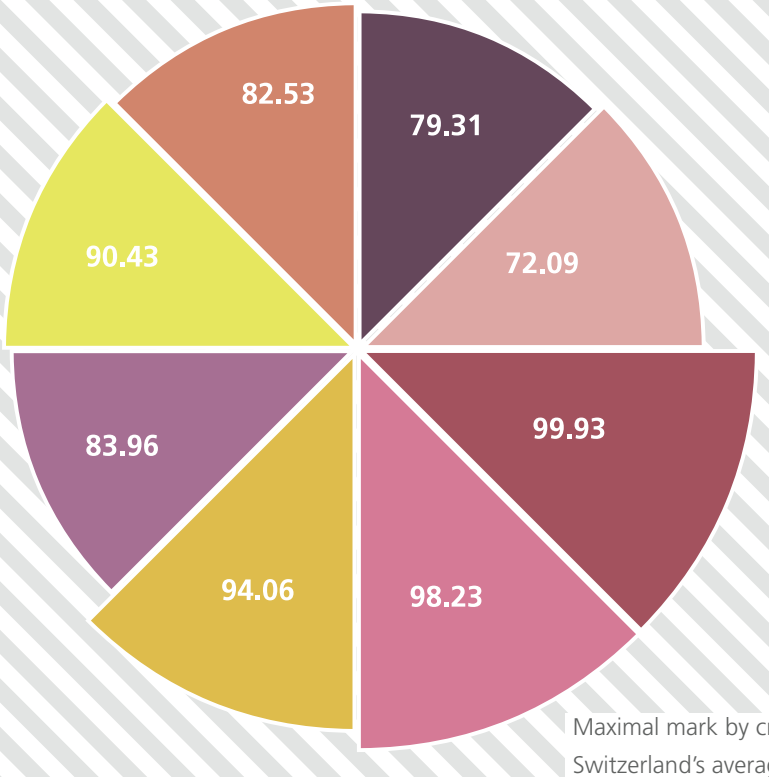
- Restraint in the consumption of resources
- Transparency and standards on raw materials and products
- Ecologically aware design of products and processes
- Waste prevention
- Closing materials cycles
- Sector-specific approaches, such as the role of the financial markets
- International engagement, such as evaluation of the impact of trade agreements on the environment
- Consolidation of knowledge, such as the integration of cleantech aspects in all professional training
- The promotion of dialogue, in particular between the economic sectors, the scientific community and public bodies



Colored photovoltaic panels at the Swiss Tech Convention Center in Lausanne. A product commercialised by Solaronix, based on a technology developed at the Swiss National Institute of Technology in Lausanne (EPFL).

# Innovation - facts and figures on cleantech in Switzerland

## *ENVIRONMENTAL PERFORMANCE INDEX: THE PROFILE OF SWITZERLAND*




Climate and energy

Biodiversity and habitat

Forests

Agriculture

Health impacts

Air quality

Water and sanitation

Water resources

Maximal mark by criterion: 100
Switzerland's average mark: 86.93
Rank number 16 of 178 countries

Figure 02: Environmental performance index. (Source: Yale, 2016)

## GLOBAL INNOVATION INDEX (GII)

In 2016, for the sixth consecutive year, Switzerland occupied first place in the Global Innovation Index (GII, 2016), ahead of Sweden, the United Kingdom, the United States and Finland. This global index, published jointly by Cornell University in the United States, the business school Insead, and the World Intellectual Property Organization (WIPO), reviews 141 countries, evaluating their capacity for innovation based on 79 indicators. Switzerland is particularly noted for its environmental performance.

## ENVIRONMENTAL PERFORMANCE INDEX (EPI)

From a purely environmental point of view, Switzerland was placed 18th in the Environmental Performance Index in 2016, based on 20 criteria divided into nine categories: health impacts, air quality, water and sanitation, biodiversity and habitat, water resources, agriculture, forests, fisheries, climate and energy. This result represents a real vote of confidence for the citizens' and politicians' choices made during the last 30 years.

## GLOBAL CLEANTECH INNOVATION INDEX (GCII)

A more specific focus on the cleantech sector potential is given by the Global Cleantech Innovation Index (GCII), issued in 2014 by the World Wildlife Fund and the Cleantech Group, which investigates 40 countries for their ability to foster entrepreneurial clean technologies. This report uses a wide range of factors and sources to examine which countries have the greatest potential to produce entrepreneurial cleantech start-up companies.
Switzerland scores in the top ten in the GCII. Room for improvement exists in the area of fostering cleantech SMEs and start-ups with incentive programmes to promote the energy transition.
A look at the patents relating to clean technologies, in particular those dealing with the environment, confirms the dynamism of the cleantech economy in Switzerland. A detailed analysis by Prof. Heinz Müller of the Swiss Federal Institute of Intellectual Property, shown below, sheds an interesting light on the subject.

## CLEANTECH INNOVATIONS ARE REFLECTED IN PATENTS

Globally, the proportion of cleantech patents out of all patents ever published is about 3 per cent. Despite this small number, it is a significant share of the total number of patents since areas such as biotechnology have only a 2% share of all patents worldwide. Furthermore, the proportion of cleantech patents has grown steadily, with a 30% increase over a 10-year period (from about 3.3% in 2005 to about 4.4% in 2015).
As Switzerland is a small country, it is not surprising that the number of patents originating from here amounts to only around 1% of the cleantech patents worldwide. Interestingly, however, Switzerland ranks first in cleantech patents per capita, as illustrated in Figure 03. This figure once again illustrates that Switzerland is on the right track with increasing investments in clean technologies.

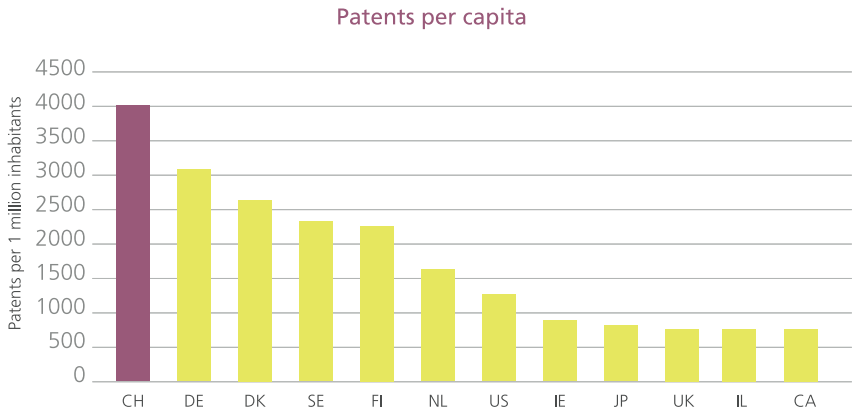



*Figure 03: Cleantech patents per capita (source: IPI, Prof. H. Müller, 2016)*

As mentioned previously, Switzerland has a strong tradition of innovation in environmental issues. This fact is reflected in the patent literature, as Switzerland is a leading nation in patents for wastewater treatment technologies and waste management including recycling, as illustrated in Figure 04.

A metric to measure patent citations has been found in numerous scientific studies to be a valid indicator of the importance of the invention. The number of patent citations is then corrected for age, patent office citation practices and the field of technology. This results in a Technology Relevance metric, which is a relative measure for comparing the patent to other patents. Such calculations can be performed for a set of patents, such as all patents in a given technological field in one country.

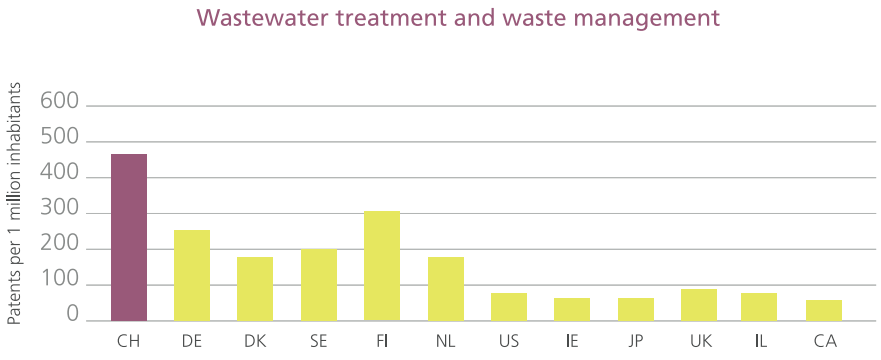



*Figure 04: Patents per capita for wastewater treatment and waste management (source: IPI, Prof. H. Müller, 2016)*

Figure 05 shows the Technology Relevance (TR) index of all cleantech patents for different countries. The TR index of Switzerland (CH) and Germany (DE) is slowly declining, whereas there has been no significant change in countries such as the U.K. and the U.S. over the last 10 years. Interestingly, the Technology Relevance index increases if only the patents with joint ventures between Switzerland and the U.S. are measured (approx. 15,000 patents). This could indicate that combining the power of two high-tech countries results in a much higher TR index. This is a strong signal of Switzerland's attractiveness for partners in the cleantech field.

Another outcome of this analysis is the high dynamism of Swiss research institutes in the cleantech field, as underlined by two facts. Firstly, a higher percentage of cleantech patents are issued from academia when compared to all cleantech patents originating in Switzerland. Secondly, twice as many patents from universities are issued in the cleantech field (4%) when compared to all other technological fields (2%).

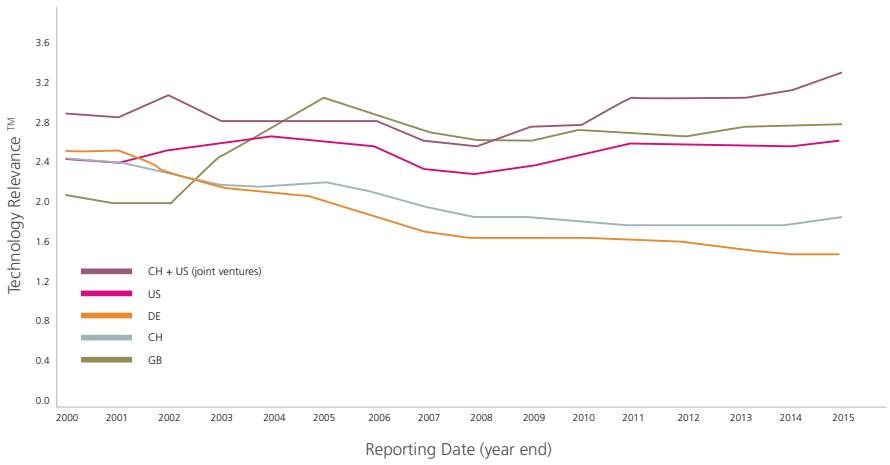



*Figure 05: Technology Relevance of all cleantech patents for different countries (CH, D, US, UK) and a combination of countries (CH + US), (source: IPI, Prof. H. Müller, 2016)*

Switzerland, an example for waste valorisation: biomass sorting for compost and biogas production.

## RESEARCH INSTITUTES

Swiss research is built around a very close-knit, high-quality network that constitutes one of the pillars of innovation. The proximity and interconnection between the research world and the business sector form the second essential pillar of this ecosystem. The higher education system currently comprises ten regional universities, the ETH Domain (Federal Institutes of Technology in Zurich – ETHZ, and Lausanne - EPFL, Swiss Federal Institute of Aquatic Science - Eawag, Swiss Federal Institute for Forest, Snow and Lanscape Research - WSL, Swiss Federal Laboratories for Materials Science - Empa and Paul Scherrer Institute - PSI), other university-level institutions, nine universities of applied sciences and 14 teacher training schools. The Swiss universities enjoy an excellent position in the university and research communities of Europe and the rest of the world. The Federal Institutes of Technology in Zurich and Lausanne, for example, are ranked among the 15 best in the world according to the "QS World University Rankings 2015".

Significant investments are made by the public and private sectors to guarantee the quality of the Swiss institutions. By way of example, the Swiss Confederation and the cantons invest more than 4.6 billion euros per annum in research and innovation. More than double this amount (10.5 billion euros) is invested annually by the private economy.

## DEDICATED AGENCIES, TOOLS AND PROGRAMMES

Innovations and the development of new solutions in the cleantech fields benefit from specific incentive programmes implemented by major public players. In this context, the Commission for Technology and Innovation (CTI), help transform the fruits of scientific research into commercial results (see infobox).

### CTI, SWITZERLAND'S OWN AGENCY FOR THE PROMOTION OF INNOVATION

CTI is the innovation promotion agency of the Federal Administration. It supports numerous research and development projects pursued jointly by companies and research institutes. CTI also offers courses and coaching sessions for start-up companies and potential entrepreneurs and stimulates knowledge transfer between researchers and companies. Through its Energy Funding program, CTI funds and manages the Swiss Competence Centres for Energy Research (SCCERs), covering the wide range of topics that are key to the future of the country, such as storage, mobility, utilising biomass and energy efficiency in buildings and industrial processes.

The Federal organisations, in particular the Federal Office of Energy (SFOE) and the Federal Office for the Environment (FOEN), have demonstrated their proactive approach and expertise with the incentive schemes they have implemented. A sum of more than 140 million euros per annum has been allocated to projects relating to the green economy and the energy transition.

With the aim of ensuring global support for the cleantech ecosystem, the Swiss Confederation (State Secretariat for Economic Affairs (SECO), SFOE and FOEN) has mandated Switzerland Global Enterprise (S-GE), the Swiss centre of excellence for internationalisation, with the management of a cleantech programme.

The programme's objective is to support the international competitiveness of the Swiss export industry in the global growth market of cleantech. It provides three main services also to cleantech companies as described in the boxes below.

### *EXPORT PROMOTION*

Working on behalf of the Swiss Confederation, represented by the State Secretariat for Economic Affairs (SECO), Switzerland Global Enterprise (S-GE) uses its expertise in internationalisation to help Swiss companies, especially SMEs, identify and develop new business potential on a worldwide basis. It provides regular information about relevant trends in the global markets, as well as professional advice and support in finding contacts and partners, and identifying new business opportunities.

### *SWISS CLEANTECH COMPANY DATABASE CUBE*

This database of Swiss cleantech companies, known as the Cleantech CUBE, is a basis for communicating services and for promoting companies both in Switzerland and abroad. Registration is free.
**www.s-ge.com/cube**

### *INVESTMENT PROMOTION*

As part of its remit from the Swiss Confederation and the cantons, Switzerland Global Enterprise (S-GE) provides potential foreign investors with information about Switzerland as a business location. Its services for foreign companies include assessing the potential of their projects before they are presented to the cantons. S-GE assists the cantons with the relocation of foreign companies, providing market and trend analyses and coordinating the activities of all the bodies involved.

The "UmweltArena" in Spreitenbach: an innovative building and an exhibition platform for sustainability. It produces approximately 40% more energy than it needs to cover its own needs (without exhibitions).

# INNOVATION HIGHLIGHTS

To gain a more detailed view of this expertise, we invite you to take a look through the cleantech highlights portfolio that we have compiled for you.
Here you will see the implementation of pioneering developments in water treatment, mobility, materials, reduction of $CO_2$ emissions, photovoltaics, energy efficiency and smart grids.
We have chosen to bring you portraits of some innovative SMEs, reflecting the fact that companies of this kind make up 99% of the Swiss economic fabric.

# NEST
## Residential experiments in the building laboratory

Laboratories are not usually inviting spaces that encourage you to stay around. But things are different at the site of Empa, the Swiss Federal Laboratories for Materials Science and Technology in Dübendorf (canton of Zurich). A building laboratory has been built here in which guests can even come to stay, thereby becoming an integral part of the research projects.

The new building on the Empa site in Dübendorf is the size of an imposing apartment building, and several apartments could be housed on each of the four floors. "Could" is the operative word, however, since the building, occupied since mid-2016, is no ordinary residential building. NEST – its official name – actually houses laboratory units where scientists examine issues surrounding the buildings of the future. There are 15 laboratories in this unique research and innovation platform. Their joint aim is to test technologies, materials and systems under real conditions in order to develop them further.

**There are 15 laboratories in this unique research and innovation platform.**

### BUILDINGS, ENERGY, WATER

The 'Meet2Create' laboratory, for example, was designed by the School of Engineering and Architecture at the Lucerne University of Applied Arts and Sciences. The laboratory recreates an office environment, in order to research aspects such as flexible furniture, personalisable workplace climates and building facilities designed to passive criteria in meeting rooms. In another laboratory unit, called 'Vision Wood', Empa and ETH Zurich scientists have established a residential module for students. Here they examine which innovative functions and applications can be fulfilled by timber as a material in a residential context. One of NEST's partners is Eawag, the Swiss Federal Institute of Aquatic Science and Technology. With its 'Water Hub', the institute is investigating the reuse of water, developing new concepts for obtaining nutrients and energy from waste water.

A permanent component of NEST is a platform dedicated to energy research. The aim of the 'ehub' (short for Energy Hub) is to improve energy management at district level. The 'ehub' is designed to be inclusive, intelligently bringing together all the components in NEST that generate, store, convert or release energy. "With NEST we are researching energy-efficient solutions using renewable energy sources, and developing innovative solutions for technical building facilities. These involve key technologies for a wide range of cleantech applications," says Empa Director Gian-Luca Bona.

## INSPIRATION FOR A GREEN ECONOMY

NEST offers companies a platform to accelerate innovation processes. Here, companies meet researchers whose work is oriented towards practical uses and who promote the transfer of knowledge gained from research to the economy. Around 100 partners have become involved in the project to date and the numbers are likely to grow in future, since the laboratory units should provide space for new research projects after five to seven years in operation. This means that NEST will continually renew itself, keeping abreast of the latest issues facing building and energy research.

Scientists' work is oriented towards applications in demand in the marketplace. In order to ensure this, one part of the laboratories is occupied. Doctoral students have moved in to 'Vision Wood', enabling the researchers to gain direct feedback on their investigations into the residential applications of timber. Guests are also welcomed into the 'HiLo' laboratory unit, where ETH Zurich is researching adaptive facades and new lightweight construction methods in a two-storey residential and workplace environment. All this will enable NEST to produce new cleantech applications that really have been devised for people.

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# CSEM
# Solar panels for facade cladding

White and coloured modules developed by Swiss researchers (Prof. C. Ballif and PhD L. E. Perret from PV-Center / see picture) have put photovoltaic panels well on the way to conquering building facades – bringing considerable potential for the decentralised production of renewable energy.

The drab aesthetics of traditional photovoltaic panels, with their blue and black colours, often represent an architectural constraint. In order to resolve this problem, the CSEM – Swiss Centre for Electronics and Microtechnology – has developed coloured panels (in particular, white and terracotta) for optimum integration into the walls and roofs of buildings in our towns and cities.

The principle is as follows: a nanotechnology film is affixed to standard crystalline silicon solar panels. Acting as a filter, it enables infrared waves to pass through to the solar cells while the surface reflects the full spectrum of visible light. In optimum conditions this results in electricity production of 90 to 130 W/m$^2$, depending on the colour.

## A FIRST IN THE DESIGN WORLD

This innovative film is being prepared for mass-production by Neuchâtel company Solaxess. They have developed a partnership with the Belgian company ISSOL, which markets the first white and coloured photovoltaic panels, and has recently established a site in Neuchâtel. It has a total photovoltaic production capacity of 100,000 m$^2$ per annum.

This is a first in the design world, opening the doors to numerous perspectives for building-integrated photovoltaics (BIPV). As well as the aesthetic advantages, since these concealed modules can be integrated into all surfaces of a building without being limited to the roof, they increase the surface area that can be dedicated to a building's energy production and efficiency. The modules are complete structural elements, substituted for other elements of the shell such as render or sheeting, which results in a considerable reduction in construction costs.

## LOCAL ELECTRICITY PRODUCTION AND SMART CITIES

Increasing photovoltaic surfaces, thereby relocating production to the heart of towns and cities, also means that the sites of energy production and consumption are brought closer together. At present, many solar farms are located tens of kilometres away from the urban areas they serve. Since photovoltaic power is not easily transportable, this results in significantly reduced efficiency.

**In optimum conditions this results in electricity production of 90 to 130 W/m$^2$, depending on the colour.**

The CSEM is also setting itself up as a centre of excellence for the development and mass-production of low-consumption cells. In another energy efficiency sector, the centre has contributed to the deployment of LoRa technology in the city of Neuchâtel. This technology enables objects to communicate and data to be transferred at lower fixed costs, with solutions that are less power-hungry. Digital and energy technologies are brought together with microtechnology to bring about numerous new applications for smart cities.

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# Planet Horizons Technologies
## Electromagnetism for sustainable agriculture

A physical water treatment process reduces the consumption of chemicals and energy. Developed for irrigation water, it can also be used in other sectors.

Throughout the world, the water used for irrigation is becoming increasingly saline. This results in a significant reduction in yields, a restriction on the varieties cultivated and soil that is so salt-saturated that agriculture is unsustainable. On top of this, root-knot nematodes are now a major problem in most crops: the Food and Agriculture Organisation of the United Nations (FAO) points out that 18% of global production is destroyed by these microscopic worms, which attack the roots of plants and cause a significant fall in crop yields.
Electromagnetic treatment of irrigation water is an environmentally-friendly and inexpensive method that helps farmers to combat these problems of salinity and nematode infestations. Aqua-4D® has been developed from 2004 onwards by the Sierre-based company Planet Horizons Technologies, and is now one of the world's leading systems in this field.

### HIGHER YIELDS

Based on the effect of electromagnetic fields, this treatment alters the behaviour of the minerals and organic matter in water. It improves the dissolution and distribution of minerals in water, the ability of the soil to retain water, and the absorption of minerals by plants, while maintaining a healthy balance of bacteria, having an adverse effect only on plant-pathogenic nematodes. Aqua-4D® makes it possible to use irrigation water that has a high mineral content, while maintaining high yields. In addition, there is a gradual leaching effect on soils that are already salt-saturated. The alteration in the physical properties of the water results in a finer and more even distribution of the mineral salts and nutriments. They remain more easily dissolved in water and those that are not absorbed by the plant are drawn beneath the rhizosphere (root area). Improved water retention produces savings in water (25% on average) and fertilisers (30% on average), while also increasing crop yields by up to 20%.

### A MODULAR AND ECONOMICAL SOLUTION

This environmentally-friendly solution does not use any chemicals and consumes only a very modest amount of electricity (it can be powered by small solar panels). In addition, it is modular and easy to install, allowing an unrestricted and efficient flow of water over several kilometres. The system has two basic modules, a pre-programmed electronics unit to produce the electromagnetic signals, and

pipes designed to transmit them into the water. Aqua-4D® is now requested and recommended by a growing number of farmers throughout the world. They report a rapid return on investment, varying from 1 to 2 years on average.

**This environmentally-friendly solution does not use any chemicals and consumes only a very modest amount of electricity.**

The process developed by Planet Horizons Technologies has many applications beyond the irrigation sector, particularly in animal husbandry, where it can improve the health of livestock by eliminating the biofilm on water supply pipes. In the construction sector, it can prevent and eliminate mineral and organic deposits in pipes, also preventing them from corroding.

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# IMMARK
## The safe dismantling of toner cartridges

If used printer cartridges find their way into waste incineration plants they can cause a dust explosion. Sabine Krattiger and her company, IMMARK AG, have recently introduced a safe recycling process to prevent this.

Nowadays, printers are as much a part of the household as cookers and coffee machines. The number of used printer cartridges is correspondingly high. A proportion of empty cartridges are refilled with toner, but even so, around 1,200 tonnes of printer/copier cartridges are disposed of in Switzerland every year.

Unlike cookers and coffee machines, printer cartridges present problems when it comes to disposal. This is due to the dusty consistency of the toner powder, which is released into the environment when the cartridges are dismantled. The toner powder can build up in the waste incinerator plant storage bunkers and cause dust explosions. Moreover, from an ecological point of view, toner cartridges should ideally not be incinerated, but taken apart to recover recyclable materials.

### RECYCLING MADE POSSIBLE

In 2015, the company IMMARK AG in Regensdorf (canton of Zurich), which specialises in the recycling of electrical appliances, started up an innovative disposal plant for toner cartridges. The company's plant not only disposes of toner cartridges safely, but also succeeds in recycling a substantial proportion of the materials. The recovery of plastics and metals (iron, copper) enables a recycling percentage of 66% to be achieved. This unique disposal plant has been given financial support from the Swiss Federal Office for the Environment (FOEN).

The new disposal process uses an additive that adheres to the toner powder and binds the dust-like particles. Moreover, the plant is designed to ensure that even if a small explosion does occur, there is no damage to the machinery. The IMMARK specialists are currently working on a way to recycle the toner-additive mixture, focusing on the building industry as potential users. If this idea proves successful it will push the recycling percentage up to 90%.

**Today, almost half of the toner cassettes disposed of in Switzerland are properly dismantled in Regensdorf and the components put forward for recycling.**

### SWISS WASTE DISPOSAL EXPERTISE

Today, almost half of the toner cassettes disposed of in Switzerland are properly dismant-

led in Regensdorf and the components put forward for recycling. In the coming years, the proportion of recycled toner cartridges will increase further thanks to the new process. This Swiss innovation is also attracting attention abroad. The company, which has a workforce of 80, has received enquiries from German and U.S. companies interested in replicating the Swiss toner recycling plant in their own countries.

Exporting technology know-how abroad is nothing new for IMMARK. "Ever since the company was founded in 1986 we have been pioneers in environmentally friendly waste recycling and disposal," says managing director Sabine Krattiger. In recent years, her company has exported disposal plants to various European companies, and even China. Expertise from the canton of Zurich is making a substantial contribution to closing material cycles globally.

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# Imperix

## Networks that are more intelligent and reliable

A Swiss company operating in the field of power electronics has implemented technology capable of controlling and coordinating complex systems – a kind of revolution.

Over recent years the strong take-up of renewable energies has caused a surge in the need for and interest in power electronics systems. Known as converters or inverters, they are essential in particular for the integration of renewable energies into the grid or for the long-distance transportation of large quantities of electrical energy. At the interface between information technology and electricity, inverters are complex devices that require their manufacturers to invest heavily in research and development before launching them on the market. At the same time, the fact that inverters are indispensable for the electricity grids of tomorrow makes them of great interest to academics, in particular those whose studies involve the topic of smart grids.

The Sion-based company Imperix currently supplies laboratory equipment to engineers working on the design of inverter prototypes in both industrial and academic environments. In a field where the development of each inverter type has to date been very specific, with few transferrable elements, Imperix is now supplying universal blocks – power modules, control units, sensors – that can be quickly assembled and put into use.

### BUILDING BLOCKS FOR SMART GRIDS

This approach enables the company's clients to make savings in development times, and also enables newcomers, who may not immediately possess all the skills or technical resources they need, to work on the development of tomorrow's inverters.

The company, located on the Energypolis site, works closely with EPFL and the Swiss engineering schools and has most notably developed the BoomBox, a control platform for inverters. An industrial computer dedicated to facilitating the creation of inverter control software for its customers, the BoomBox also provides smart grid operators with an easy way to test and validate the control strategies of tomorrow using realistic inverters.

**The BoomBox provides smart grid operators with an easy way to test and validate the control strategies of tomorrow using realistic inverters.**

### SCALABLE TECHNOLOGY

This represents a revolution in the field of power electronics, with massive potential for development in the years to come. Imperix is already finding more general applications for its technology by enabling manufacturers to integrate it directly into their products, thereby reducing their complexity. In the short term, this may affect all equipment that transforms electrical energy, such as the production and storage of energy from renewable sources, or electrical drives. The longer-term objective of Imperix, a company that has the rare potential to become one of the leaders in its field, is to make its technology increasingly scalable. For example, its increased modularity and its redundancy mechanisms will make the control of very large installations, such as wind or solar farms, more flexible, more reliable and less expensive.

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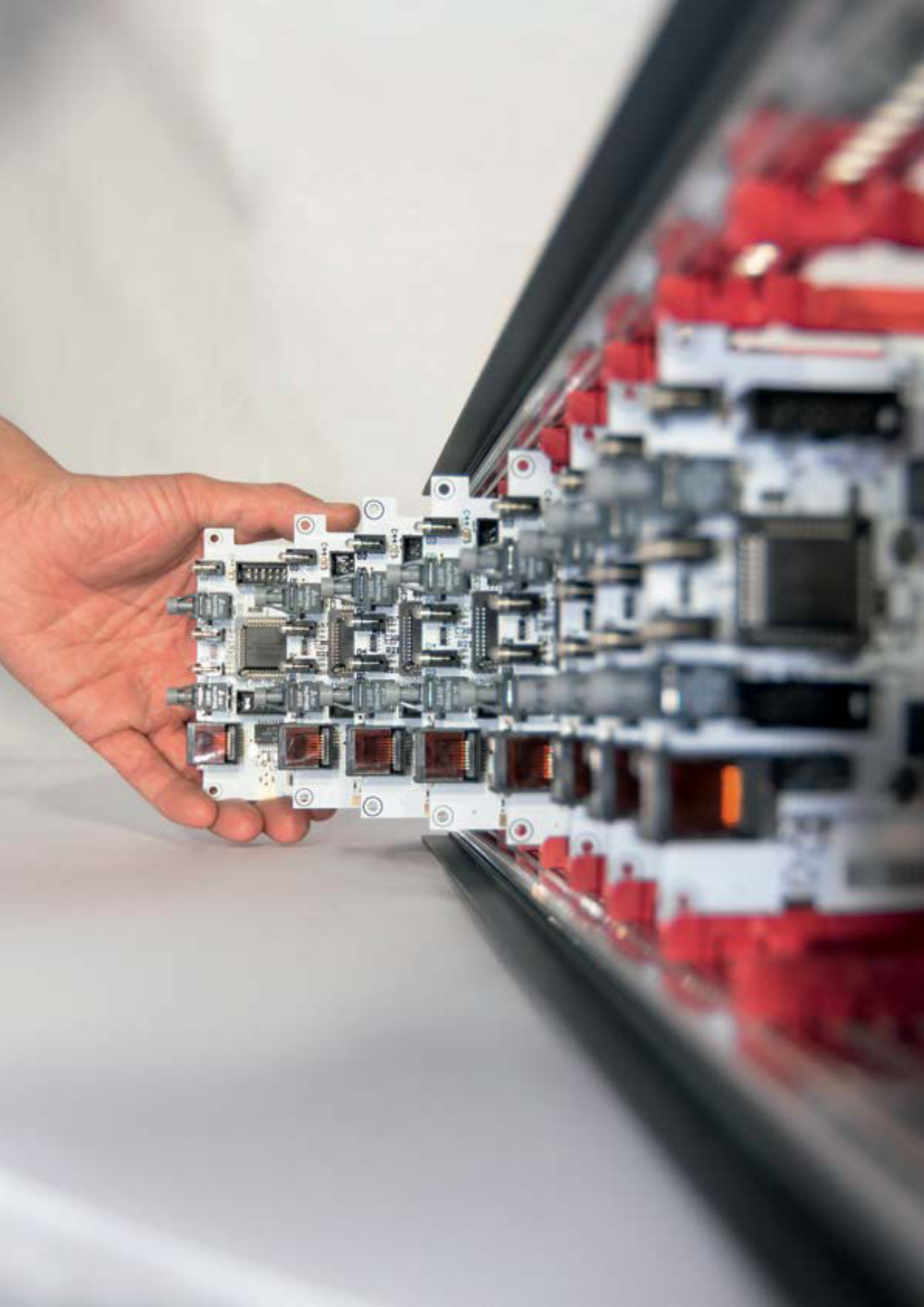

# Swiss Fresh Water
## Inexpensive drinking water for poor communities

Swiss Fresh Water offers low-income communities an independent, low-cost system for desalinating brackish water. The first machines were set up in Senegal and are controlled remotely from Switzerland.

When Renaud de Watteville, the founder of Swiss Fresh Water, was travelling in Africa, he saw that most villages were unable to turn brackish water (which has an intermediate level of salinity that makes its use problematic for human beings) into drinking water. In 2008, after two years of R&D, he designed a machine that operates using a generator or solar power and can treat up to 4,000 litres of water per day via an osmosis process. The system reduces the salinity of the water from between 1 and 8 grams per litre to between 30 and 100 milligrams, and also eliminates bacteria, viruses and heavy metals, which cause conditions and illnesses such as fluorosis, diarrhoea, and hypertension.

### UNDERSTANDING THE LOCAL ECOSYSTEM

An initial project, launched in Senegal in 2011, confirmed the high demand for this water desalination system. Like other Swiss companies involved in environmental technologies, Swiss Fresh Water shows a tremendous capacity to adapt to the context in which its clients live. Indeed, the roll-out and acceptance of this solution in the field are directly related to the understanding of the local ecosystem. Furthermore, in this type of approach, it is essential to be able to guarantee total transparency of governance. For this reason, the machines are owned by a specially-created foundation. Swiss Fresh Water is concerned with the development, sale, and repair of the installations.

**The project currently has 100 machines in use, providing drinking water to some 250,000 people.**

The project currently has 100 machines in use, providing drinking water to some 250,000 people. Three people are employed at each site to maintain and repair the equipment. Swiss Fresh Water uses new information technologies to deal with maintenance and support from Switzerland via the internet: information related to network activity is received in real time, which means that local operators can be given advice as quickly as possible.

### A WIN-WIN BUSINESS MODEL

The business model is based on the win-win principle, which is a way of maintaining a certain balance. When the machines have been installed, the water is then sold for between 0.3 and 1.5 euro cents per litre, and half the income generated remains in the village in order to pay the fixed costs such as salaries and electricity. The other half is used by the foundation to finance the maintenance and amortisation of the machines and, where applicable, to install new machines in other villages.

Swiss Fresh Water aims to continue creating jobs, reduce rural depopulation and improve the health of local people, and has already created 300 jobs in Senegal (3 jobs per machine). Its objective of operating in new markets is becoming reality, with five machines soon to be installed in Bolivia, thanks to support from the Swiss Agency for Development and Cooperation.

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Bien plus que de l'eau
FCFA, le litre
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# Skyflor®
# A green lung for towns and cities

Born from a combination of nature and innovative technologies, a Swiss green wall system offers vertical oases of greenery, while also opening up new ways of recycling grey water.

Climatic disturbances and pollution are changing urban climates, creating notable islands of hot and dry conditions. At the same time, the ongoing expansion of impermeable surfaces also results in water management problems. In order to improve the physical and mental well-being of residents, while restoring humanity to the urban environment, growing density in towns and cities must be accompanied by the creation of more green surfaces.

These various findings are behind the perfection of the Skyflor® green wall system developed by HEPIA – Haute école du paysage, d'ingénierie et d'architecture de Genève, member of HES-SO University of Applied Sciences and Arts Western Switzerland. This patented system, marketed by the Swiss company Creabeton Matériaux, is made up of three elements: a ceramic layer with interconnected porosity, a mineral substrate and a base of ultra-high performance fibre-reinforced concrete (UHPFRC).

## NATURAL AIR CONDITIONING

Skyflor® enables vertical surfaces in urban spaces to be sown with any kind of plant that can thrive in this particular situation. As well as the aesthetic improvement offered by a green wall of this kind, the system also improves the quality of urban life. For example, it enables plants to grow on streets that do not have enough space for them to take root in the ground.

Green facades also add life and colour, revamping grey urban surfaces. They also reinforce biodiversity and have the role of natural air conditioning. Against a background of climate change raising temperatures in towns and cities, Skyflor® improves urban microclimates by keeping streets cooler and fresher in summer. The system also reduces and absorbs noise.

**This technology is a major piece in the jigsaw puzzle of the smart cities of tomorrow**

## MODULAR FACADE ELEMENTS

This technology is a major piece in the jigsaw puzzle of the smart cities of tomorrow, especially now that people are showing an ever-increasing desire to reappropriate their towns and cities. It also contributes to humanising the construction industry and demonstrates companies' commitment to conservation of resources. It should be noted that all three layers of the system (concrete, substrate and ceramic layer) are extremely thin. The mounting of the prefabricated elements of the system directly on the loadbearing structure eliminates a number of stages and considerably reduces construction times. The versatile facade elements are modular in design and come in a variety of sizes.

Irrigation is simple – Skyflor® is equipped with an automatic system that requires little maintenance and only needs moderate water consumption, as it can also draw on rainwater. Various ways of recycling grey water for green-wall watering are also being explored. In brief, it is an ideal way of bringing a little of the natural world back to the towns and cities of the future.

Skyflor® is a typical example of innovation process through private and public partnerships. This green wall system comes from Mr Kaufmann's dream (the inventor) and has been turned out into reality with the help of creative professors Daune, Perroulaz and Monge from HEPIA. Combined education and research is one of the innovation pillars of Switzerland.

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# Sorba Absorber
## Ammonia filter from corn stover

When livestock holdings and sewage treatment plants release ammonia, this air pollutant is perceptible as an unpleasant smell. Sorba Absorber GmbH (Biel/Bienne) has developed an innovative ammonia filter that uses a renewable raw material: the leftovers from harvested corn.

Neighbours of poultry farms, pig farms, sewage works and composting plants are only too familiar with the pungent smell of ammonia. This nitrogen compound is a basic chemical product – and at the same time an air pollutant that is one of the main causes of the formation of acid rain. The Gothenburg Protocol, in force since 2005, aims to reduce the worldwide emission of ammonia. Switzerland was among the countries to ratify the protocol. Today, in cantons such as Zurich and Zug, ammonia filters are obligatory.

Ammonia filters clean the outgoing air from livestock holdings and sewage treatment plants before it is released into the environment. Sorba Absorber GmbH in Biel/Bienne has now developed an innovative filter process that uses a naturally occurring substance derived from corn plants as the filter material. This cleantech innovation provides for a clean environment and contributes to the circular economy by using raw materials available in the region.

### SPONGELIKE NATURAL MATERIAL

The naturally occurring BABS (bio-absorber) substance is impregnated with sulphuric acid to bind the ammonia in the form of ammonium sulphate, a salt used in agriculture as a fertiliser. The BABS is produced from the spongy tissue of corn stalks and can absorb large quantities of sulphuric acid. When the outgoing air is fed through a container filled with impregnated BABS, the BABS is saturated with ammonium sulphate after two to three months – at this point, it can be spread on the fields as fertiliser. Sorba Absorber GmbH started developing the use of BABS as a filter material in 2014 with the School of Engineering and Architecture of Fribourg, and tested it in three pilot plants in 2016.

Ammonia filters are not new. The current state of the art is represented by chemical scrubbers, in which the outgoing air is fed through a sulphuric acid shower. In these systems, a pump is required to recirculate the acid, and the ammonia-saturated liquid has to be stored in reservoirs until it can be spread as fertilizer in the following spring or summer. "Our process doesn't require any pumps or complex control technology, or reservoirs," says Stefan Grass, founder and managing director of Sorba Absorber GmbH. He goes on to explain that the BABS absorber is very simple to use and entails much lower investment costs than chemical scrubbers.

**The Absorber is very simple to use.**

## REPLACEMENT FOR PEAT AND REDUCTION IN $CO_2$ EMISSIONS

In corn cultivation, the stalks are generally unused. Sorba's new process does not just use the spongy tissue from the stalks as an ammonia filter – the company goes one step further: Sorba has developed an application for the outer layer of the corn stalk that encases the spongy tissue inside. This outer layer is mechanically shredded and, under the name of TEFA, used as a substitute for peat, whose depletion leads to the destruction of moorlands and – since these are important $CO_2$ sinks – the release of large quantities of $CO_2$. With TEFA, the company is contributing to the replacement of a fossil raw material whose mining is illegal in Switzerland, but which is still imported in significant quantities. For the past two years, TEFA has been marketed in Switzerland by a wholesaler as a component of peat-free compost. The innovative recycling of corn stalks is of interest for all corn-growing regions. In addition to the domestic market for this Swiss cleantech innovation, Stefan Grass is particularly looking to Germany, the Netherlands and France as export countries. With his company, he shows how marketable products can contribute to air pollution control and resource conservation.

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# Hangar 55
## Electrifying aerobatics

For a long time it looked as though environmentally friendly electric motors were not powerful enough for the aviation industry. An electrically powered aircraft by Valais aerobatics pioneers has now disproved this assumption.

In 2015/16, Bertrand Piccard and André Borschberg circumnavigated the globe for the first time in a purely solar-powered aircraft, the 'Solar Impulse'. And with the SolarStratos project, aviation pioneer Raphaël Domjan from Western Switzerland intends to enter the stratosphere in a solar powered aircraft. These examples show that drive systems using electricity from renewable sources have a future not only on the ground, but also in the air. The people at the start-up Hangar 55 are also convinced of this, and the company has joined forces with partners from the industry to develop a battery-powered stunt plane that, once charged using electricity from renewable sources, flies completely without $CO_2$ emissions. It achieves record-breaking ranges – electrically powered aircraft to date have achieved a flight time of around ten minutes, while the new plane has stayed in the air for 45 minutes, including 30 minutes' energy-intensive aerobatics, without a drop of kerosene.

### INTEGRATING EXISTING COMPONENTS

Land of $CO_2$ free electricity, especially hydropower, Valais offers the ideal environment for the development of low $CO_2$ emission applications like the electrical powered mobility. It is little surprise, therefore, that it was in the Rhone valley, near Raron, that the 'Hamilton aEro' – the name of the electric plane – took to the air in autumn 2016, after an eighteen-month development period, to the amazement and delight of the crowd who came to watch. This maiden flight was made possible by the developers, with technological support from their main sponsor, Hamilton, incorporating the very latest available components into an ultra-light high-tech aircraft. The fuselage is made from fibreglass and carbon composite, the Siemens electric motor gives maximum power for minimum weight and the aircraft including batteries weighs in at just 326 kg. Allowing around 100 kg for the pilot and equipment, this gives a maximum start weight of 420 kg.

Hangar 55 has brought to life the design for a stunt plane suitable for series production in record time. The company is made up of three passionate pilots: Thomas Pfammatter, Dominique Steffen and Sébastien Demont. Demont was the leading electrical engineer for the 'Solar Impulse' project. He also has prime res-

**The plane has stayed in the air for 45 minutes, including 30 minutes' energy-intensive aerobatics, without a drop of kerosene.**


ponsibility for the heart of the innovative plane – the battery management system. The main task of this system is to monitor the 108 battery cells, and it has the capability to shut down any individual cell, e.g. if there is a threat of overheating. A proportion of the electricity is recovered during the flight by converting to electricity the kinetic energy of the rotor produced during a dive.

## GRASPING FUTURE MARKET OPPORTUNITIES

"In ten years, most stunt pilots will be flying on electricity," says Thomas Pfammatter. "Electric planes are cheaper, quieter and more ecologically sound than their fossil fuel-driven predecessors." With their electric plane, the Hangar 55 pioneers demonstrate how the Swiss industrial network can be used for innovative solutions and the market opportunities they bring. With their battery management system, they are supplying a key component for electric plane manufacturers. Hangar 55 also intend to produce their own stunt planes in small series. The follow-up model to the 'Hamilton aEro' is to be even more high-performance and manoeuvrable – good enough to delight the crowds who come to watch complex aerobatics competitions.

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# Renggli
## Swiss quality timber housing

Timber houses are the embodiment of traditional qualities and cosiness. The 'swisswoodhouse' from Renggli AG, based in Sursee, combines these benefits with excellent energy efficiency and a modular building concept.

Despite its location in a rural region of the canton of Lucerne, Nebikon is nevertheless a centre of construction innovation – it was here in 1999 that Switzerland's first passive energy buildings were built. The five terraced houses are so well insulated that they do not need conventional heating. Recently, a second vision has become reality in the immediate vicinity. An energy-efficient building called 'swisswoodhouse', constructed to a modular plan from prefabricated timber sections, was done here.
18 tenants have moved into the apartment building over the last two years.

**Modern timber buildings are at the top-quality end of the scale.**

The four-storey structure with its shimmering grey-green timber facade satisfies the most stringent energy standards. Certified according to the Minergie-P-Eco Standard, the building gains its heat from a ground-source heat pump and produces photovoltaic electricity from solar panels on the roof. A measurement project carried out at the Lucerne University of Applied Sciences and Arts has confirmed that it achieves the ambitious planned values. The Swiss Federal Energy Office (SFEO) has supported the project in its pilot and demonstration phases.

### TIMBER FROM SWITZERLAND

The 'swisswoodhouse' is made largely of wood, with additional materials being used where needed and as required by the fire protection regulations in force at the time. For example, the stairwell and basement were concreted, and cement screeds were used for embedding the underfloor heating, a widespread type of heating system today, which runs on low supply temperatures. The timber beamed ceilings include a layer of limestone chippings for sound insulation and to contribute towards heat insulation in the summer. The building's static loadbearing system comes primarily from the facade and individual steel supports.
The ventilated facade cladding is made from Swiss timber, and the remaining elements were constructed using timber from the European Alpine region. The manufacture of the prefabricated timber elements at the Renggli AG factory in Schötz took a mere three weeks, and the assembly on site was completed within a further three-and-a-half weeks.

### COMFORT AND YIELDS

Renggli AG in Sursee (canton of Lucerne) constructed the timber building as general contractor with a number of partners. The original concept is currently being developed. It is possible to use the 'swisswoodhouse' in Nebikon as a basis for hybrid construction versions, with the aim of ensuring sustainability with regard to the construction process, layout and day-to-day running. Timber apartment buildings are currently popular both in Switzerland and abroad. Modern timber buildings are at the top-quality end of the scale – the building in Nebikon has a range of high-quality extras, such as metal window frames, spacious loggias with timber decking and comfort ventilation.
Max Renggli, CEO of the family firm, sees the completed project as a valuable showcase property, which will reinforce confidence in the outstanding quality of timber construction. "We want to appeal to investors who are seeking a balance between yields, the requirements of the 2000-watt society and attractive comfort and living conditions."

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# Hydros
## A floating laboratory

The catamaran Hydros is not only the pure essence of speed, it is the perfect illustration of the important role played by technology in improving the efficiency of boats.


The shipping sector carries over 90% of the world's trade and is the fifth-largest source of pollution in the world. The Hydros Foundation, based at EPFL's Innovation Park, has set itself the mission of promoting technological innovation as a response to energy and environmental issues in the sailing and shipping industries, and also of raising awareness of these problems among professionals, students, opinion-formers and the general public.

Launched in 2010, the hydrofoil catamaran Hydros.ch is the Foundation's ambassador. The fastest boat in Switzerland, with three prestigious Lake Geneva speed records, it is a superb tool for raising awareness and also for conducting experiments. It can sail at 2.7 times the speed of the wind, and illustrates perfectly the role played by technology in the quest for efficiency.

### FLYING BOAT

The development of flying boats within the world of sailing put the spotlight on their amazing energy efficiency. It was foil technology in particular that produced rapid advances in performance while also reducing energy consumption. A foil is an underwater wing that moves in the water and transmits a lift force to the boat, which enables it to "fly" and, as a result, reduces its friction in the water.

The Foundation organises events that include the Little Cup, the international class C championship founded in 1961. This is a technological as well as a sporting competition, which has led to developments such as rigid wings, and it is often considered to be the ideal test event to prepare for the America's Cup. The participation of some of the most efficient boats yet designed – extremely light catamarans that can travel at three times the speed of the wind – makes the class C championship into an innovation laboratory where the latest technologies are tested, pitted against one another and approved.

### FLUID DYNAMICS

One example of the cutting-edge expertise developed by institutes such as EPFL is the software designed by Hydros, which is used to optimise boats, in particular through the use of computational fluid dynamics (CFD).

**This technology is used in competitions, but can be applied to all types of vessels, including sail cruisers, cargo ships, and yachts.**


This technology is used in competitions, but can be applied to all types of vessels, including sail cruisers, cargo ships, and yachts. To take a cargo ship as an example, CFD studies can calculate its resistance to forward motion and analyse its flow characteristics, enabling the designers to optimise its shape and thus reduce its energy consumption. These simulation technologies could potentially be used in other sectors, such as the aerospace industry.

The Hydros Foundation also offers an educational ecosystem within which innovative ideas and key actors are brought together. It fosters new initiatives and supports the development of solutions that will optimise the energy efficiency of boats, whether these are maritime transport vessels, competition race boats or yachts. As part of this approach, it organises the annual Hydrocontest on the Lake of Geneva, the first international competition devoted to energy efficiency in boats.

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# Schmid Energy Solutions
## Heating and electricity from unprocessed waste wood

The focus of today's wood-fuelled heating systems in the range up to 5 MW is mainly on heat production. Schmid AG in Eschlikon (canton of Thurgau) has developed a wood-fuelled heating system that delivers both heat and electricity. This innovative power plant, with an output of 500 kW thermal and 100 kW electrical power is tailor-made for the decentralised, $CO_2$-neutral supply of energy for municipalities and local districts.

Düdingen has a population of around 8,000. Since autumn 2015, the municipality in the Sense District, canton of Fribourg, has been bringing a new district heating network into operation in stages. One year on, all the municipal buildings and around 180 households have been connected to the system. The combined heat and power system is operated by the Western Swiss energy supply company Celsius Groupe E.

### DECENTRALISED HEAT AND ELECTRICITY PRODUCTION

The heating network in Düdingen has a central energy system that is unique worldwide: as well as a standard wood-burning furnace, a Schmid AG hot-air turbine has been installed that produces electricity as well as heat. The power plant closes a gap in the market, as in this size class, the supply of decentralised heating and power using the native, $CO_2$-neutral energy source of wood was to date only possible using gasification that requires substantial preparation of the fuel and high technical capabilities on the part of the operators. The energy plant used in Düdingen is suited to the supply of heating networks serving typically around 180 households, and the electricity produced can supply the requirements of around 250 households. Plants of this kind can make a contribution towards the implementation of the Federal Council's Energy Strategy 2050, which has led the Swiss Federal Office of Energy (SFOE) to support the wood-fired power plant as a showcase project.

### INNOVATIVE HOT-AIR TURBINES

Schmid AG, who have specialised in biomass heating systems for 80 years, spent seven years developing the power plant together with various partners. The hot-air turbine consists of a standard grate-fired furnace for a wide range of unprocessed fuels. The wood furnace is fitted with an air-exhaust gas heat exchanger, and the air heated here is discharged via two turbines that produce electricity. The excess warmth is then diverted off to an air-water heat exchanger.

**An example of competitiveness**

"One of the major advantages of the hot-air turbine compared to conventional combined heat and power systems for timber biomasses (e.g. steam turbines, ORC plants, wood gasifiers) is that we are working with a very low-risk medium: hot air", says Philipp Lüscher CEO of Schmid AG. "Unlike systems that are operated with superheated steam or thermal oil, the risk of accidents is kept to a minimum. Hot air as a medium also allows for simpler system technology and therefore low maintenance costs. Another substantial plus compared with carburettor systems is the use of unprocessed small-diameter wood, which can be used with a moisture content of up to 55%, without any pretreatment. This has a considerable positive effect on the fuel costs of heating plants of this kind."

### USE IN SWITZERLAND AND ABROAD

The example of Schmid AG shows how Swiss SMEs can prove their competitiveness with their cleantech innovations. A wood-fired heating plant with hot-air turbines can achieve an excellent overall efficiency level of 77%. The use of the latest electrostatic precipitators reduces the impact on the environment from dust pollution to a minimum.

Philipp Lüscher is aware of many locations in Switzerland that would be ideal for the installation of a hot-air turbine. This cleantech innovation from the Swiss family firm has also attracted considerable interest from countries such as Austria, Italy and Japan, and the export promotion organisation Switzerland Global Enterprise (S-GE) has supported Schmid AG in entering the North American market and their development of the hot-air turbiness.

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SCHMID

# NVTerra
## Chemical-free drinking water

NVAqua is a turnkey water purification system. It provides an environmentally-friendly solution for developing countries, and could also be used in water treatment plants.

Almost 700 million people worldwide do not have access to an improved water source, and 1.2 billion people simply do not have any drinking water at all. What can be done for them? Since 2010, a Swiss company has been developing an innovative water treatment technology based on research and inventions by the French electrochemist Jean-Marie Fresnel. The interchangeability of the modules that make up this mobile, "green" turnkey system means that it could also be used at environmentally-friendly mini water treatment plants.

### WHO STANDARD ACHIEVED

"We've designed a machine that can purify almost any surface water", explains Jean-Marc Rogivue, co-founder of Bühler Electricité Monthey (BEM) and its spin-off, NVTerra. An electrolysis process plus salt and iron make it possible to produce a disinfectant (sodium hypochlorite) and a coagulant (Ferilec) to eliminate phosphates, nitrates and heavy metals from water. Sterilisation or disinfection alone is not always sufficient to make water drinkable, so these toxic substances must also be removed from it. In this way, almost all water can be brought up to the standard of treatment recommended by the World Health Organisation (WHO). The special feature of the process lies in the preliminary treatment: water can subsequently be treated using techniques such as ultrafiltration or reverse osmosis. The production of reagents in situ is a decisive factor for the rest of the purification processes, in particular because it prevents the filters from becoming clogged. The company's aim is to produce 30 litres of drinking water per person per day in communities with between 1,000 and 10,000 inhabitants. In addition, all the machines are fitted with a system that enables them to be monitored remotely: the pilot unit at Addah, in Côte d'Ivoire, is monitored from Switzerland.

**The company's aim is to produce 30 litres of drinking water per person per day in communities with between 1,000 and 10,000 inhabitants.**

### CONCLUSIVE TESTS

The technology is also intended for use as a complementary physico-chemical and biological treatment at the outflow from small water treatment plants,

for example at the outflow from planted filters (the phyto-purification system used in environmentally-friendly mini water treatment plants). In this situation, the technology known as NVSani could offer an alternative to standard treatment systems that use harsh chemicals such as iron chloride ($FeCl_3$), which is used in the majority of water treatment plants. Up to 1,000$m^3$ of waste water could be treated in this way every day.

After major R&D work during the last three years, NVTerra is going to continue the development of its project in Côte d'Ivoire and establish itself in North Africa and in France. Trials carried out in Morocco for four months in 2015 are likely to result in a tender proposal for two villages in the Atlas Mountains. The company is planning to carry out tests in France in 2017, in relation to tertiary treatment (elimination of micro-pollutants) and planted filter systems (environmentally-friendly mini water treatment plants).

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# Meyer Burger
## For greater PV efficiency

Meyer Burger is convinced that the system's costs per kWh can only be consistently reduced by improving the efficiency of the solar modules. This is not achieved through any single technology alone, but through a combination of various factors along the whole of the PV value creation chain.

The performance and measurement parameter "$/kWh" is influenced by the total manufacturing cost of a module together with the installation and commissioning costs, with the electricity production of the module throughout its whole service life playing a crucial role. Today's module manufacturing costs are based on the quantities of silicon, glass, film and various other materials used. In contrast, the unit cost relating to hours spent and materials used in the installation of a solar module is roughly consistent. There are therefore two ways in which costs can be driven down: better utilisation of materials and lower installation costs due to higher-output modules, and therefore fewer units overall.

Meyer Burger has addressed these factors by developing new technologies that achieve greater output per module while substantially reducing manufacturing costs. This achieves much more favourable overall costs in relation to the system output, because there are significant improvements to both parameters – "$" and "kWh" – and this has a corresponding leverage effect on the price. The developments mean that a system consisting of 10 modules can typically produce 30% more energy, thus achieving a noticeable cost reduction. In other words, the same energy yield can be achieved, for example, from 7 modules instead of 10, which results in substantial savings (30% for the modules, 70% for the installation). This means that, in future, the energy efficiency (kWh) per $m^2$ will be an important measurement parameter in the solar industry.

### FEWER MATERIALS AND HIGHER ENERGY EFFICIENCY

Roughly speaking, the production of solar modules is divided into three areas: wafering, cell coating and module manufacture. Each area offers various opportunities to reduce production and material costs, while simultaneously increasing efficiency.

**Separation technology**: At the wafering stage of the process, Meyer Burger is able to cut 135µm thin wafers with only 75µm kerf loss (using 60µm diamond wire), producing around 84 wafers per kilogram of silicon – in contrast to earlier technologies that only yielded 40 wafers per kg of silicon. This alone leads to a massive reduction in the cost of the starting materials.

**Cell technology**: Previously, very thin wafers were associated with the risk of lower cell efficiency. Now, heterojunction (HJT) cell technology enables these thin wafers to be processed

into highly efficient solar cells. Due to the cell's physical properties, its efficiency actually increases as the wafer thickness decreases (down to 100µm). From a starting point of 22%, cells with up to 25.6% efficiency have already been achieved. Moreover, this technique makes bifacial use possible, which substantially increases performance.The second way of coating cells efficiently is by using Passivated Emitter Rear Cell (PERC) technology. This is ideal for customers who want to upgrade from standard coating and achieve an absolute increase of 1%.

**Module technology**: SmartWire Connection Technology (SWCT) is the latest generation of cell connections. The benefits of SWCT over the standard busbar technology are clear – by using round wires with diameters of only 200 300µm, surface shading is reduced to the absolute minimum, resulting in up to 7% greater module output. Costs are also reduced as less silver is used and handling is more straightforward. The development of these integrated technologies and the appropriate materials has led to the production of modules with an unprecedented performance, ensuring the future competitiveness of solar energy when compared with conventional energy sources.

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# RedElec
## From jeans to water treatment

Initially developed for the solubilisation of indigo dye, a Swiss electrochemical process is now being used for numerous industrial applications.


Switzerland is one of the cradles of electrochemistry, a prime example of sustainable technology since it involves the transformation of one substance into another of greater added value, without the use of chemical products. Several significant industrial processes have capitalised on this technology since the middle of the last century, most notably the production of chlorine, hydrogen and aluminium.

RedElec Technologie, based in Riddes, has developed a system that perfectly illustrates the potential of sustainable chemistry unleashed by electrochemistry. This spin-off from the Swiss Federal Institute of Technology in Zurich (ETH Zurich), which has built up specialist skills in industrial electrochemistry, has developed and patented an electrochemical reactor.

### ECOLOGICAL TEXTILE DYEING

This system is particularly useful in the textile industry, enabling jeans, for example, to be dyed in an environmentally friendly process. Indigo, used to colour blue jeans, is insoluble in water, and has to be made soluble prior to the textile dyeing stage. The usual method requires a chemical reagent that is harmful to the environment, because it generates a large quantity of salt in the effluents from the dye works. Its sensitivity to air also causes its quality to deteriorate during storage.

The technology developed by RedElec does away with the need to use this harmful reagent, as it makes indigo soluble by the direct use of electricity. The process is already established on an industrial scale by an Italian denim manufacturer.

### MULTIPLE POSSIBILITIES, ESPECIALLY IN THE TREATMENT OF POLLUTANTS

The industrial applications of electrochemistry remained limited for a long time, for reasons of cost and the restricted choice of available materials.

Today, against a background of growing environmental pressures, the arrival of new materials that may be used in an electrochemical reactor, and the rising prices of raw materials, electrochemistry has become a very competitive, promising technology.

**The process is already established on an industrial scale by an Italian denim manufacturer.**


The process developed by RedElec also enables the generation of highly oxidising compounds (hydroxide radicals), which are very effective in breaking down non-biodegradable pollutants. This makes it possible to treat aqueous industrial effluents to make them compatible with subsequent treatment in waste water treatment plants (WWTP). RedElec works for pharmaceutical companies to provide treatment facilities, initially as a laboratory pilot and then on site. Its areas of expertise also include the removal and recovery of metals and the treatment of emulsions.

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# ZAV Recycling
## A waste recycling plant goldmine

When waste is incinerated at waste recycling plants, residues of filter ash and slag are left behind, which contain recyclable metals. ZAV Recycling AG in Hinwil (canton of Zurich) have developed a new process for reclaiming fine-grained metals from the slag.

Most of the household and industrial waste from the Zurich Oberland region is processed at Hinwil, where it is incinerated in the Zweckverband Kehrichtverwertung Zürcher Oberland (KEZO) waste incineration plant. Around 200,000 tonnes per annum of waste are incinerated and used to generate electricity and district heating. The incineration process results in around 40,000 tonnes per annum of slag, which has to be deposited in landfill sites.

Around ten years ago, the operators of the Hinwil waste incineration plant and the Office for Waste, Water, Energy and Air of the Canton of Zurich (AWEL) set an ambitious target: to ensure that in future the slag would no longer have to be deposited in landfill sites. "We realised that the slag contains numerous recyclable materials, which we want to reclaim as fully as possible," says Daniel Böni, Managing Director of the Hinwil waste incineration plant.

### DRY PROCESSING OF SLAG

The vision has made a leap forward towards realisation in 2016, when a processing plant for dry slag was brought into operation at the waste incineration plant site in Hinwil. Dry slag refers to slag that is no longer cooled using water on leaving the incinerator, as used to be the practice, but is dried using an intake of cold air. This has considerable advantages for downstream processing – in particular, fine metal residues are easier to recover for recycling from dry slag.

**The new plant enables the yield of metals from slag to be increased by 30 to 40% from previous levels.**

Slag contains around 10% iron and a further 3.5% of metals such as aluminium, copper, brass and even precious metals such as gold, silver and palladium. The new plant enables the yield of metals from slag to be increased by 30 to 40% from previous levels. This improvement is due primarily to the fact that the new plant can also separate out fine-grained metal residues. The benefits are two-fold: firstly, from an ecological point of view, because small metal particles can cause substantial environmental harm. Secondly, from a financial point of view, the value of the recovered metals is high enough for the dry slag processing plant to be operated on a profitable basis due to the income from sales.

### METALS IN A VERY CLEAN FORM

The plant, built by ZAV Recycling AG, is the first of its kind worldwide. It is dimensioned so that a third of the slag generated in Switzerland can be processed here, and enables metals of a very clean quality to be recovered. To date, dry slag from the waste incineration plants at Hagenholz (ERZ, City of Zurich), Horgen, Monthey (SATOM) and Zuchwil (KEBAG) are delivered here for processing. "We have had many visits from foreign specialists who are interested in our system. They want to use our know-how in the renewal of their own plants," says KEZO Managing Director Daniel Böni.

The results to date have been very pleasing, but the operators of the dry slag processing plant want to take things further. Metals are currently being recovered from the slag successfully, and good results are also obtained from glass. In future other mineral products are to be separated out from the slag and reintroduced into the materials cycle as raw materials or building materials. This means that the vision of the full recycling of slag is gradually becoming reality.

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# HES-SO Valais-Wallis
## Smart grid infrastructures unique in Europe

How can the challenge of an energy transition encouraging renewable energy sources best be met? Two institutes at the forefront of eEnergy (software and data related energy issues) and the physical simulation of networks enable researchers at the HES-SO Valais Wallis - the University of Applied Sciences Western Switzerland - to provide specific responses for those involved in the energy sector.

Decentralised electricity production, network stability, consumption control and economic optimisation are major issues facing the industry, local authorities and energy producers. In the context of the development of renewable energies, how can network efficiency be optimised and the best possible balance between production and consumption be ensured? By bringing together IT and energy technologies, and by facilitating the stability of electrical networks, smart grids play an essential role in the energy sector, as confirmed by research carried out in close collaboration by research carried out in close collaboration by two dedicated platforms: Gridlab and eEnergy Center.

### ENERGY OPTIMISATION, ECONOMIC BENEFITS

With its "EDAAS" (Energy Data As A Service) platform, which allows for the scalable integration of all the data connected with the field of energy, the eEnergy Center promotes the development of new services, the testing of business models, and the simulation of the economic benefits of different approaches.

In particular, the researchers offer an improvement in the prediction of renewable energy production. The financial stakes are significant – if a producer does not provide the amount of electric current contracted with the network manager, it will be penalised. This makes technical/economic optimisation essential. One solution developed for an electricity producer therefore relies on the optimisation of its energy account: based on the data from the previous day and the weather forecasts, the system provides a prediction for the coming 24 hours with a hitherto unequalled degree of precision.

**Europe's unique test laboratory for smart grids.**

The eEnergy Center is also developing information management tools, in particular proposing a low-frequency network infrastructure (LoRa) for the immersion testing of services with a view to improving daily energy consumption management.

### PHYSICAL SIMULATIONS ON THE TEST BENCH

In a practical environment that closely matches reality, Gridlab provides a service for trialling solutions that guarantee the stability of electrical networks of the future, in particular by studying the integration of renewable energies and storage. The configuration of this test bench, which is unique in Europe, enables the researchers to test various combinations covering the whole technological value chain of energy, from production to storage, also including transport, distribution and the multiple, decentralised injection of energy into the medium-voltage and low-voltage networks.

The questions associated with dispatching the current are addressed by means of a 1:5000 scale model of a hydroelectric plant and its network, a photovoltaic production unit and a wind turbine. The testing of equipment and, in time, software solutions, enables the behaviour of new products to be characterised and their further development to be accelerated.

Another issue facing future energy production, which is addressed by Europe's unique test laboratory, is the decentralised production of electricity by consumers, an aspect that needs to be controlled so that the network is not overloaded. A 1:1 scale reproduction of the distribution network of a district where the buildings are both producers and consumers of electricity is made available to the industry for the simulation of actual or envisaged situations.

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Group 1
High Head
Spherical Valve
oup 4
Solar

# CLOsac
## A toilet that keeps water systems clean

Constructing WCs is hardly the sexiest occupation, says Philipp Untersander. That's as may be, but the toilets produced by the entrepreneur from St. Gallen are a paragon of cleanliness.

Out of sight, out of mind – this maxim is certainly true in relation to flushing toilets. Fortunately, sewage treatment plants are able to remove most of the contamination from the water that enters the sewers from WCs. However, even the most modern sewage treatment processes have their limits – it is impossible to remove all traces of medicaments, cosmetics and chemicals from waste water. Micropollutants therefore represent a considerable proportion of the contamination in today's waters.

One source of these persistent pollutants is from hospitals and care homes. X-ray contrast agents, chemotherapy drugs and other medicaments are used frequently in these institutions, and through the patients' excretions generally reach the sewerage system untreated. From there, some of these traces reach the water systems that form the basis of the drinking water supply.

### AIRTIGHT AND ODOUR-TIGHT ENCAPSULATION

Philipp Untersander has got to the root of the problem. With his family firm, CLOsac AG, he has developed an innovative toilet that flushes without water. Human excrement does not reach the sewer system, but faeces and urine are sealed, hygienically and odour-free, in a plastic film from a dispenser in the toilet seat. Packaged in this way, the excrement – depending on the type of contamination – is disposed of in a standard waste incineration plant or properly burnt in a high-temperature furnace.

**This product is the answer to the high requirements placed on the cleaning of industrial waste waters.**

Several Swiss hospitals have already opted for the dry WC, known as the Rollac 1.0. Because the toilet does not need a water connection, it can also be used on a mobile basis, making it more convenient for use by dialysis patients or those in isolation rooms. Philipp Untersander also believes that the Rollac is the answer to the high requirements placed on the cleaning of industrial waste waters by the water pollution control legislation.

### LIGHTER AND CHEAPER

The mobile dry toilet from the town of Grabs in the Rhine valley near St. Gallen has also received considerable interest from hospitals in Austria and Germany. Following production of the first 50 units, the second generation, the Rollac 2.0, is set to be introduced to the market in 2017. The weight of the toilet, currently only 76 kg, will be reduced even further.

The price, based on a use-related lease fee that includes disposal of the excrement, will also be reduced further as production volumes grow.

The basis for the waterless toilet was developed in a project that lasted several years by researchers at the University of Applied Sciences and Arts Northwestern Switzerland in Muttenz (canton of Basel-Landschaft). Established companies initially turned their noses up at the new development. But Philipp Untersander grasped the opportunity and presented the prototypes of the Rollac in 2014. Three years on, he now has is cleantech innovation ready for mass deployment on the market.

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# Novaccess
## The Internet of Things at the heart of smart towns and cities

A solution developed in Switzerland enables municipal authorities to control their expenses relating to public lighting. It combines the intelligent management of street lamps with a vehicle for innovative communication services.

Urban centres face the challenge of controlling the energy consumption of their public lighting systems. Providing lighting where it is needed, with the necessary brightness but no more, could lead to significant energy savings in the order of 30 to 50%. This means that a town with a population of 140,000, which spends almost spends almost 900,000 euros on conventional public lighting, could make a total saving of between 260,000 and 480,000 euros.

In order to provide an effective response to this issue, the company Novaccess, based in Yverdon-les-Bains, has developed a solution that it calls NovaLight. This intelligent public lighting system enables the physical street light network to be controlled centrally, superimposing on it an information network that uses the latest Internet of Things technologies. The result is not only energy savings, but also a reduction in the logistical costs of industrial services.

### SECURE MANAGEMENT OF SMART CITIES

The integration of control units in street lights enables the remote, centralised rationalisation of maintenance, minimisation of truck and cherry-picker movements or reconfiguration of lighting systems in just a few clicks, in particular for special occasions such as sports matches, major events or firework displays. The ubiquitous street lamps in a town also provide an ideal, far-reaching network to support the implementation of a global communications solution. Towns and cities are forced to use multiple costly IT solutions for the control of numerous applications (street furniture, information signs, parking facilities), running the risk of breaches of security.

The NovaLight system has therefore been developed to manage all these applications, housing them all in a single secure management cockpit. Based on the public lighting network, this technology offers a smart city-type solution, enabling a municipal authority to manage several applications and mutualise the Internet of Things network.

### COORDINATING COMMUNICATION INTERFACES

Novaccess is at the core of the Society 4.0, with its platform for the remote control of objects, sensors and machines. The heart of the technology is a multi-interface, multi-application and multi-role electronic module developed specifically for the Industrial In-

**Based on the public lighting network, this technology offers a smart city-type solution, enabling a municipal authority to mutualise the Internet of Things network.**

ternet of Things. It allows various communication interfaces (GSM/GPRS, 3G, Ethernet or Bluetooth) to be coordinated around it, creating bridges to other Internet networks.

This company is one of the products of the innovation ecosystem supported in particular by the Commission for Technology and Innovation (CTI). This support has enabled it to combine the key skills needed to develop controllers, working together with IT security and software architecture researchers from the HES-SO at Yverdon.

Like a substantial number of Swiss companies who choose partnerships with foreign companies, Novaccess also works with the company BMTC, based in Dubai, a leading enterprise in the United Arab Emirates for the supply and installation of electrical equipment for industrial applications and public lighting.

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# La Cigale
## Ice: keeping energy in cold storage

A heating system that combines heat pumps, ice batteries and solar thermal roofing has been installed in a 1950s residential development. Solar energy now provides 76% of the energy used for heating and domestic hot water.

Buildings account for almost half the energy consumed in Switzerland, and many boilers are currently oil-fired. In a context of energy transition, in which the aim is to reduce dependency on fossil fuels and make buildings more energy-efficient, the renovation of two 8-storey apartment buildings in Geneva is leading the way. These buildings consumed too much energy, mainly for heating (using oil), and were radically refurbished in 2014 to improve their efficiency and sustainability. The energy used to heat them and provide hot water is now mainly of solar origin (76%), with the rest coming from a heat pump (19%) and from a gas boiler that produces additional heat during very cold periods (5%).

### MAKING THE MOST OF SOLAR ENERGY

Given the intermittent nature of solar energy, this project presented a real challenge. However, the "IceSol" system, developed by the Valais company Energie Solaire SA, provides the 273 apartments with energy all the year round, at any time of the day or night, whatever the weather conditions. To achieve this, IceSol incorporates a system that enables the energy from the 1, 700m$^2$ of solar collectors on the roof to be stored until it is used by the five heat pumps, which are connected in series, to produce energy for heating and hot water.

Each of the two buildings therefore has an ice battery consisting of a water tank at 0°C, with a unit capacity of 30m$^3$ – which means it has a latent energy storage capacity of 2031 kWh. These tanks store energy in cold water by exploiting a simple physical phenomenon: water releases large amounts of energy when it changes from a liquid state to a solid state. The batteries not only enable the heat pumps to use solar power even during the winter months, but also make use of low-temperature solar inputs to thaw the ice.

### FOR VERY WELL-INSULATED BUILDINGS

However, installing a heating system that uses an ice battery is pointless unless the building concerned is very well-insulated. The renovation of the two apartment blocks in the "La Cigale" residential cooperative was therefore also dependent on improvements in the envelope of each one. The facades were given a 240 mm layer of insulation material and clad with prefabricated wooden components, the windows were replaced and the roofs insulated. These measures reduced the buil-

dings' heating requirements by almost 70%, an improvement that enabled them to obtain Minergie-P certification. This is the highest level in the Minergie system of measuring energy performance, which was developed in Switzerland to improve the energy efficiency of new and refurbished buildings. The scale of the work makes it the largest refurbishment project in Switzerland to achieve this standard. It is a pioneering project, providing a model that could be widely replicated.

**It is a pioneering project, providing a model that could be widely replicated.**

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Solar Impulse - an idea born in Switzerland

# KEEP ON LEADING THE WAY

Thirteen years ago, when we imagined making an aircraft fly without using fossil fuel, the aviation industry said it was impossible. But we took up this challenge anyway, experimenting and finding solutions in other sectors. That's the role of exploratory projects – to show that things can be done differently, to overcome doubts. And also to persuade people of the fantastic potential of these innovations. The electric propulsion that has been tested within the Solar Impulse project is now an integral part of the R&D at Boeing, Airbus and even NASA.

Switzerland has a major role to play in the cleantech sector, as the success of our venture demonstrates. The idea of this solar-powered aircraft was born in Switzerland. The feasibility studies were carried out in Switzerland. A large number of Swiss SMEs played a part in its design. And when Solar Impulse landed in California, one of those who welcomed it was Sergey Brin, one of the founders of Google: proof positive of Switzerland's credibility in innovative clean technologies!

Switzerland has everything needed to be successful. Our researchers and our businesses are developing and exporting clean technologies with high added value, offering practical solutions to the environmental challenges that the world faces. It's a superb opportunity, not only for our balance of trade, but also for the future of the planet.

We must now continue to set an example and be even more enterprising. Switzerland has to show others the way, and be the first to take the key decisions. Boldness creates more opportunities than problems.

•

**André Borschberg,** CEO, pilot and co-founder of Solar Impulse &
**Bertrand Piccard**, President, pilot and co-founder of Solar Impulse.

www.swisscleantechreport.ch

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**Innovation Highlights**

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