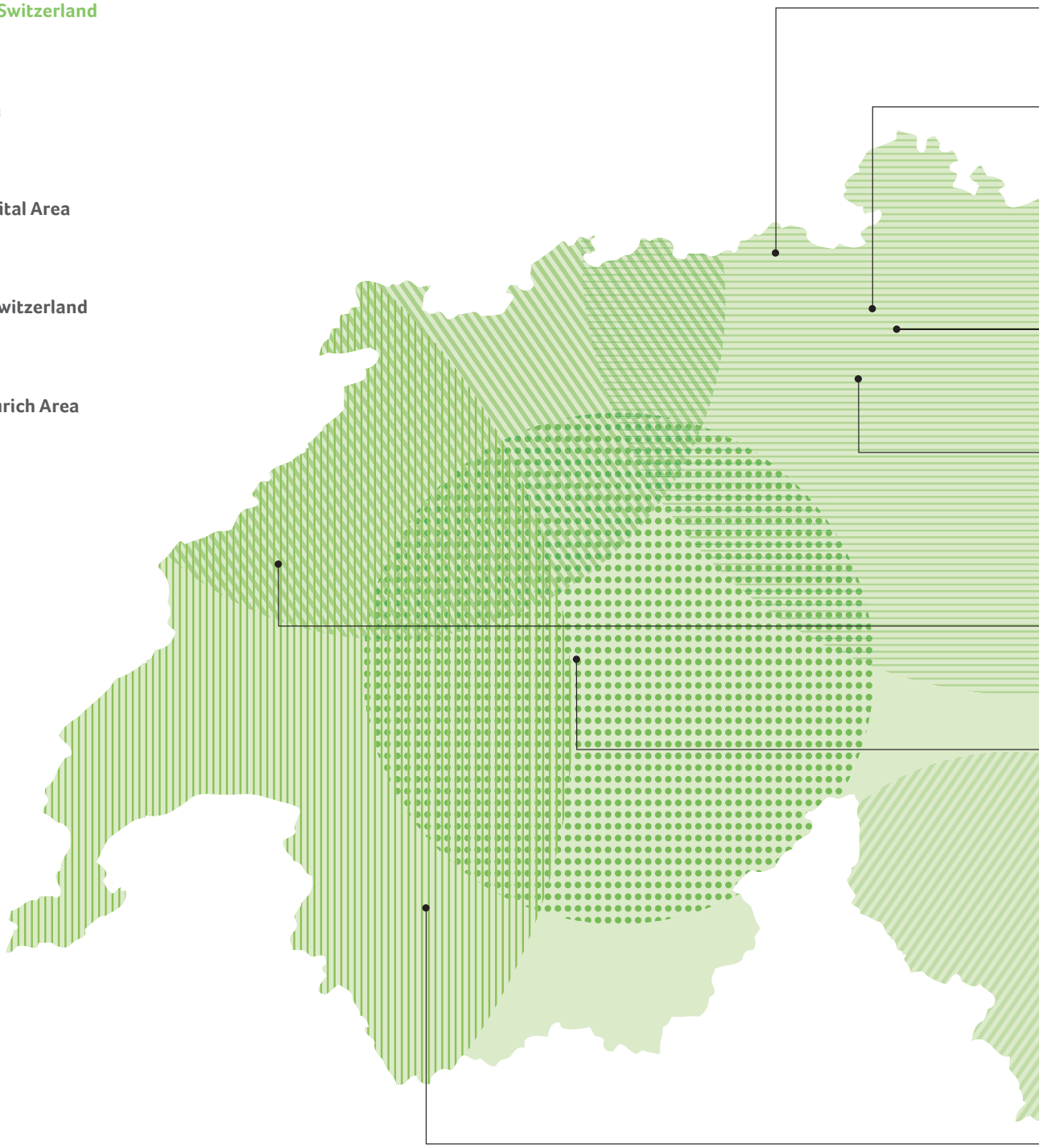
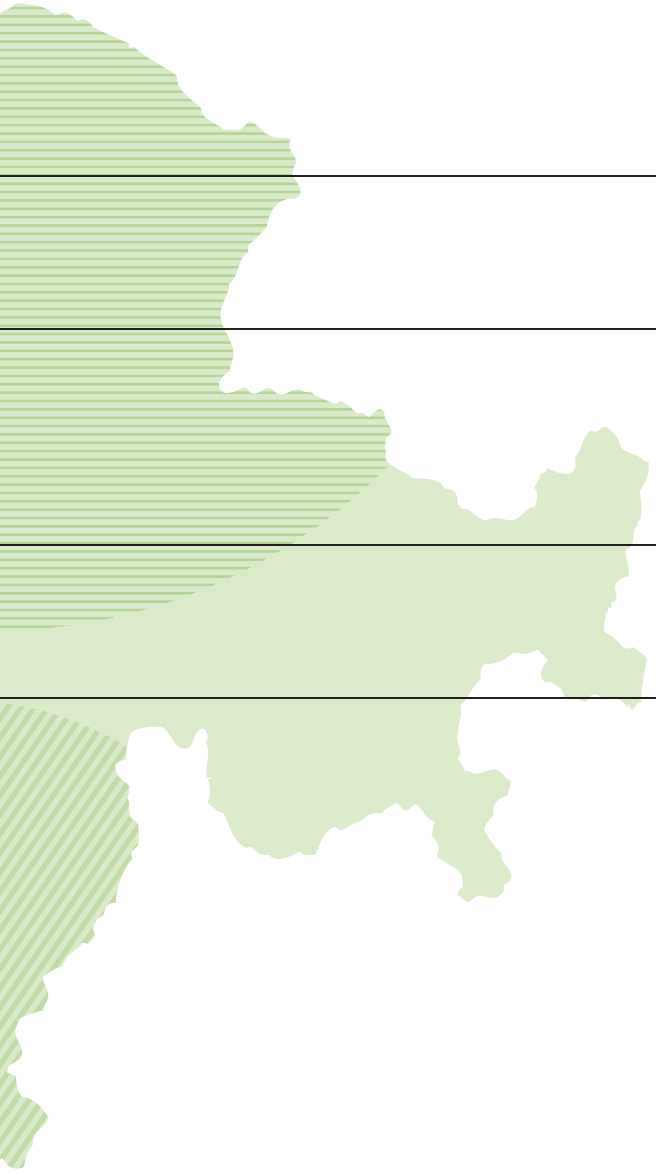
Swiss Cleantech Report 2011

Map

Economic Areas in Switzerland

- Basel Area
- Berne Capital Area
- Western Switzerland
- Greater Zurich Area
- Ticino





Paul Scherrer Institute PSI
CH-5232 Villigen PSI
www.psi.ch

SIX Swiss Exchange
Selnaustrasse 30
CH-8021 Zürich
www.six-swiss-exchange.com

Osec
Stampfenbachstrasse 85
CH-8021 Zürich
www.osec.ch

Empa
Überlandstrasse 129
CH-8600 Dübendorf
www.empa.ch

Swiss Private Equity & Corporate Finance Association
Grafenauweg 10
CH-6304 Zug
www.seca.ch

CSEM
Rue Jaquet-Droz 1
CH-2002 Neuchâtel
www.csem.ch

Federal Office for Professional Education and Technology OPET
Effingerstrasse 27
CH-3003 Bern
www.bbt.admin.ch

Swiss Federal Institute of Intellectual Property
Stauffacherstrasse 65/59g
CH-3003 Bern
www.ige.ch

swisscleantech
Thunstrasse 82
CH-3000 Bern 6
www.swisscleantech.ch

CleantechAlps
c/o CimArk Route du Rawyl 47
CH-1950 Sion
www.cleantech-alps.com

Contents

Editorial

The use of cleantech solutions and economic and social orientation towards durability are currently the most important approaches to protect global biodiversity and manage and utilize the world's natural resources in a sustainable way. A rising awareness of the importance of sustainability and cleantech must be anchored in the economy and our society alike. In addition, policymakers must establish and improve upon framework conditions that promote sustainable development.

The Swiss Cleantech Masterplan set up by the Federal government in 2010 has come up with a vision and a series of objectives that should provide fertile ground for the Swiss plans of action. The master plan was devised for the purpose of effectively strengthening the innovation capacities of cleantech companies and research institutions in Switzerland.

The following concrete objectives were included in the Master Plan:

1. By 2020, Switzerland will affirm its position in the top league of environmentally conscious countries and be at the forefront of cleantech research. The Swiss educational system and its business minded universities of applied sciences in particular have long supported the cleantech sector with both their curricula and practical research in the cleantech area. However, administrative and structural hurdles remain stumbling blocks for financial incentives and seed money to reach out for a wider audience. Another problem is the discriminative practices with which universities and universities of applied sciences are treated in the research field. There is a demand for strengthening research promotion and further action to close gaps at the administrative level as well.

2. By 2020, the framework conditions in regard of the transfer of knowledge and technology will be noticeably improved. Swiss universities of applied sciences already interact extremely well with SMEs and the industry, paving the way for additional actors to follow suit. Along with reaching the master plan's first goal it will become possible to combine private research initiatives with public promotion money.

3. There will be increasing development, demand and deployment of technologies that go easy on resources. Switzerland will become one of the world's leading locations for the production of cleantech products. The industry is encouraged to keep manufacturing and selling top products in parallel with the global market's mass products. However, to keep up with globalization trends economies of scope will be required as well as economies of scale. Such economies of scope will, in the form of collaborations, promote progress both in the economy and in the academic area.

4. Swiss quality will become a hallmark of the cleantech area as well. The Swiss economy has a global reputation for its high quality levels. But our competitors continue to follow on our heels. It is therefore crucial to mould Switzerland into an integrated hub for both knowledge and work. The Swiss Confederation, the Cantons, the economy, and the country's academic institutions of higher education must actively contribute to this goal. Academic institutions and economic associations must dedicate particularly strong efforts to the development of cleantech networks connecting all areas of Switzerland.

In this line, I welcome the new spirit of cooperation between the State, the economy and the education system to develop the cleantech sector for the benefit of Switzerland and the international community.

Albin Reichlin

Albin Reichlin
President
University of Applied Sciences of
Eastern Switzerland UAS FHO

Cleantech – sustainable fuel for Switzerland's future

Cleantech has long been a buzzword in the discussion about society. In the light of the imminent climate change, resounding transformation in the developing countries, and the constant growth of the world population, political and business decision makers have come to realize that we must increasingly rely on environmentally sound technologies in order to limit the ecological impact of our way of life and preserve the opportunities for future generations.

There is no doubt that the challenges involved are serious. The hurdles which need to be overcome are high but not insurmountable, and technologies will undoubtedly play a crucial role.

Switzerland's pioneering role

Switzerland has long been playing a leading role in environmentally sound technologies. The country was among the first industrialized nations worldwide and its textile, electrical and metal industries soon gained global importance. Industrialization strongly benefited from water power widely available in various parts of Switzerland, helping to set up industrial hubs all over the country. Water power technologies were constantly developed further and improved upon. Today, water power accounts for more than 50 per cent of the domestic electricity production in Switzerland.

But the Swiss are not only well aware of the benefits gained from nature's forces that shape our world. Recurrent natural disasters such as avalanches, floodings or landslides have sensitized the population to environmental issues as well. Moreover, most of the population lives in densely populated areas being used intensively for agricultural and industrial purposes. In light of this, it does not come as a surprise that a distinct ecological awareness developed in Switzerland early on, a fact that continues to be in evidence in popular ballots relevant to the environment. As a result, the country has nowadays one of the most advanced and innovative environmental legislation.

The societal and legal environment in Switzerland provides a permanent incentive for companies to refine technological progress and innovation in order to keep up with rising ecological standards. Unsurprisingly, Swiss companies are among the most innovative players in the cleantech field worldwide, and many of the companies most renowned for environmentally sound technologies are based in Switzerland.

The cleantech sector

What is cleantech? The term generally refers to technologies which aim to protect and maintain natural resources and the environment. Clean technologies particularly deal with the development of environmentally sound products, the decrease in materials usage and waste, the reduction of energy consumption and the mitigation of environmental impacts during the production and use of goods. Clean technologies pertain for instance to renewable energies, energy efficiency, energy storage and mobility.

In light of the pressing ecological problems and of the various areas where clean technologies may be applied, the technical and economic importance of cleantech can hardly be overestimated. Clean technologies play a crucial role in all industrialized and developing countries and will even more so in the future. Accordingly, market forecasts predict the global market volume for clean technologies to reach more than one thousand billion euro in the next ten years.

Hence, the cleantech field has drawn the attention of decision makers from both politics and business. Industrialized and developing countries alike have committed themselves to promote the cleantech field in order to benefit from its technological and economic potential. Switzerland, which saw the opportunities and potential for clean technologies early on, has made an early move to become one of the most innovative and leading countries in that area.

Excellent education and outstanding conditions for research

Excellent higher education and favourable business conditions are key factors for seminal research and development in the cleantech field. Swiss authorities have long realized that education, research and innovation play a crucial role for Switzerland's prosperity. They set the course accordingly, with the issue of a pertinent government policy (see p.6).

Switzerland boosts an impressive range of educational institutions offering technical and scientific education closely linked to research institutions and industry. This relationship not only contributes to the high quality of the country's educational system but also drives the research sector and its companies, which benefit from a large number of well-trained and educated employees as well as from innovative researchers and engineers.

Linking research and business

The research sector in Switzerland has an excellent track record: Projects in all fields relevant to clean technologies attract worldwide attention and contribute to solving the most pressing energy and ecological problems (see p.8 and p.12).

Moreover, results from the research sector persistently find their way into industry and business, helping to open up new business segments. To make the knowledge and technology transfer a success, research institutions in Switzerland interact and collaborate closely with companies from industry and other fields (see p.16).

The impressive number of educational institutions, the proximity between research institutes and companies active in the cleantech field, and the cooperation between public authorities and private third parties have led to numerous cleantech clusters in the country, where excellent research is done and pathbreaking products and services are created (see p.19 and p.44).

Finally, cleantech in Switzerland strongly benefits from an excellent location promotion, support from public authorities and attractive private financial services, helping to commercialize solutions to current and future problems (see p.21 and p.23).

Christian Soltmann
Swiss Federal Institute of Intellectual Property

Education, research and innovation as an essential mission in Switzerland

The Swiss Cleantech Master Plan

The Federal Administration's Swiss Cleantech Master Plan was devised for the purpose of improving Switzerland's innovation capacities specifically in the cleantech area. By initiative of Federal Councillor Doris Leuthard, the Swiss Cleantech Master Plan was jointly devised by the Federal Department of Economic Affairs and the Federal Department of the Environment, Transport, Energy and Communications. It calls for an initial analysis of the innovation potential and position (patents, exports) of Swiss companies on the Swiss and global cleantech market to be followed by various objectives, areas of action and recommendations. This plan should serve as a guide for actions to improve Swiss competitiveness through reinforcing innovation in cleantech solutions. Its main objective is to strengthen companies in the cleantech sector through improved coordination of scientific, business, government and policymaking fields.

Further Information

For more information about the Swiss Cleantech Master Plan please see:
www.cleantech.admin.ch

Education, research and innovation are key elements of Switzerland's successful strategy to create economic prosperity. As one of the innovation leaders in Europe and worldwide, Switzerland aims high in keeping with top innovation performance through a well-coordinated interaction of education and research institutes, the corporate world, and political authorities.

Switzerland regularly achieves high scores in international rankings for competitiveness and innovation performance. As a top European innovation leader and global competitiveness leader , Switzerland seems to have mastered the avalanche of recent economic crises in an outstanding manner. This is to a considerable degree the result of a long-term strategy of continuous private and public investments into the fundamentals of a knowledge economy. Switzerland as a small country of about 8 million inhabitants needs to make the most out of its prime "natural" resource, i.e. the "brain power" of its people.

Swiss education system – high quality and diversity

People living, studying, working, and doing business in Switzerland are well aware of the value of knowledge for making a living in a country with one of the world's highest GDP per capita.

Two thirds of young people in Switzerland benefit from vocational education and training (VET) at upper-secondary level, which provides them with a solid basis for both a successful entry into the labour market and lifelong learning. There are over 200 professional careers to choose from. The dual-track VET system consists of part-time studies at a vocational school combined with part-time apprenticeships at a host company. This ensures a continuous flow of graduates (90 per cent graduation rate) each year, supplementing a well-qualified labour force of established professionals.

Professional education and training (PET) programs provide VET certificate or VET diploma holders at upper-secondary level with access to education at tertiary B level (see graph). These programs are offered by professional colleges, which provide students with solid practical skills. Combined with established theoretical expertise, these programs open the door for managerial and specialized positions.

The Swiss higher education system at the so-called tertiary A level presently includes 10 regional universities, the two Federal Institutes of Technology in Zurich (ETH Zurich) and Lausanne (EPFL), other university-type institutions, 9 universities of applied sciences as well as 14 universities of teacher education. While the regional and federal universities offer a wide range of academic courses, the universities of applied sciences have a different profile, offering practical university-level education and training.

Swiss universities are very well positioned in academic and research communities both in Europe and worldwide. The Federal Institutes of Technology in Zurich and Lausanne, for example, rank among the top 15 in Europe and among the top 50 worldwide.

Research excellence – backbone for success

Three per cent of the Swiss GDP was spent on domestic R&D in 2008, of which 73 per cent came from the business sector, in particular the pharmaceutical, chemical, ICT, and mechanical and electrical engineering industries. Even though the bulk is spent by large companies, research-intensive SMEs form an essential part of the vital and dynamic innovation landscape in Switzerland.

Research in the public sector is the domain of universities and public research institutions, which enjoy substantial academic freedom and have achieved high

international reputation. Basic funding of public research is secured jointly by the Confederation and the regional authorities.

Public funding of Swiss university research is assigned to two major institutions. The Swiss National Science Foundation (SNSF) is Switzerland's leading provider of scientific research funding. Almost 80 per cent of the supported researchers are aged 35 years or younger. With its federal mandate, the SNSF supports basic research in all disciplines. It also invests in applied research in various scientific fields.

The Swiss Confederation's Innovation Promotion Agency (CTI) supports projects of applied and market-driven research and development that are conducted jointly by companies and Swiss universities. The CTI also provides assistance to start-up companies with funding open to all scientific disciplines. Project partners are allowed to define their projects independently. The main funding criteria are innovative potential and economic impact.

Swiss universities and their research projects are largely internationalized: 45 per cent of university professors and research staff and 26 per cent of students are foreigners. This underlines Switzerland's attractiveness as a location for teaching, research and learning, and it points to a high degree of international interconnectedness and networking as well. This is also a reflection of Switzerland's multicultural context: in addition to the four national languages, English is gaining importance in business, research, and teaching.

Policy focus supports innovation and business excellence

The Swiss policy measures to support education, research and innovation are all part of an integrated policy domain, which is assessed, updated, and authorized by the Federal Assembly every four years. Education, research and innovation consistently rank high on the political agenda and enjoy concomitant funding: almost one tenth of the Swiss Confederation's annual budget is spent on higher education and research.

Along with other policy domains Switzerland has created an excellent innovation and business environment with a well educated population, open labour markets, framework conditions fostering competitiveness, attractive taxation, and a high quality of life. Public support not only includes basic funding and increasingly competitive R&D funding for public organizations, but also covers processes to build national synergies and participation in international research organizations and programs.

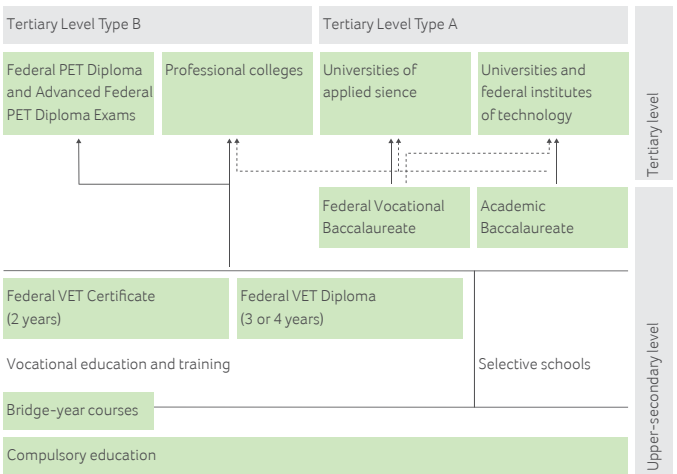
Manfred Grunt
Federal Office for Professional Education and Technology

Continuing education and training in Switzerland

The Swiss education system provides open access and permeability. Anyone who has the necessary qualifications can generally attend the course of his/her choice. There are many ways to enter or transfer to a training program or school or to attend a course to catch up on continuing education.

— Direct access
-- Additional qualifications necessary

Source: OPET



Cleantech R&D in Switzerland: Multi-faceted, interdisciplinary and top-notch

To predict that Cleantech will become big business is anything but audacious. And like in any other industry sector that heavily relies on R&D – such as pharma, biotech or medtech – the pipeline needs to be "fed" with outstanding research results eagerly awaiting transformation into products, processes or services. Switzerland offers just that – an ambitious, yet down-to-earth research scene keen on solving many of the most pressing issues in the Cleantech realm.

If one looks at some of the showcase solar projects, one is tempted to think that, for once, the proverbial Swiss modesty has taken a backseat. Take Bertrand Piccard's Solar Impulse, the self-proclaimed "Ambassador of the Future" that, in early July, completed the first ever manned night flight by a solar airplane and is due to circumnavigate the globe in 2012, powered solely by solar energy. Or the Planet Solar project, a catamaran stuffed with photovoltaics, which "set sail" in late September in Monaco to embark on a similar mission.

Together with Solartaxi, the mother of all "around-the-world" endeavours on renewable energy, these projects underpin Switzerland's oft-cited reputation as a pioneer for sustainable solutions. Kompogas from biomass waste, for instance, is a Swiss invention, and in cement production, consumption of fossil fuels was cut in half thanks to the use of alternative fuels.

Fertile ground for Cleantech

What's more, Cleantech is high on the political agenda as well. In November 2009, Federal Councillor Doris Leuthard launched a national Cleantech Initiative to gear up the Swiss economy for the global market and spread the word that Switzerland is fertile ground for all things Cleantech. To illustrate some of Switzerland's strengths in sustainable building technologies, for instance, a feasibility study has been carried out to refurbish the Swiss Embassy in Washington in line with the Swiss MINERGIE® label, equipped with "Swiss Tech" from top to bottom.

No wonder, then, that some global players have cast their eyes on Switzerland. ABB, for one, has been focusing their global Cleantech activities in Switzerland in a reflection of the country's lively, prolific R&D landscape. Outstanding results are being achieved in countless areas, ranging from the input side, the "production" or process-driven provision of materials and energy (efficiency being the keyword here) to the output side, i.e. end-of-life measures such as environmental technologies but also reuse, recycling, refurbishment and the like.

Determining the ecological footprint through life cycle assessments

To build up a green – or clean – economy, the first step is to assess whether or not a technology, process, product, etc. is environmentally sustainable. This question is far from being trivial since it is about calculating an eco-balance, an environmental life cycle assess-ment of everything that goes into said technology, process, product, including its "after-life" treatment.

Switzerland is home to the Ecoinvent Competence Center, initiated by the Swiss Federal Laboratories for Materials Science and Technology (Empa), ETH Zurich and EPFL Lausanne, the Paul Scherrer Institute (PSI) and the Swiss Federal Research Station Agroscope Reckenholz-Tänikon. The Center hosts the world's most comprehensive database for life cycle inventories, which can be used to assess the environmental impact

of, say, lithium ion batteries for electric cars or 2nd generation biofuels, as has been shown by Empa researchers in two recent studies.

A major challenge on the input side of the equation: clean energy

These examples are symptomatic for one of the major tasks ahead: how to provide enough energy from renewable sources for a growing world population and a fast-developing global economy. One idea is to use deep geothermal energy. Here, the challenge is to pump water 4 to 5 kilometers underground. In the framework of a large-scale research project, scientists at the ETH Zurich's Energy Science Center, along with their colleagues from EPFL and PSI, are exploring how rock can be made permeable to allow high-pressured water to safely circulate through it and sufficiently heat up even for electricity production, not just for heating.

Besides the Earth's interior it is first and foremost the sun that holds the promise for an unlimited energy supply. ThinPV is a Swiss research consortium, coordinated by Empa and combining many relevant academic – EPFL, PSI, the Zurich University of Applied Sciences (ZHAW), the University of Applied Sciences of Eastern Switzerland (NTB Buchs) – and industry partners as well as innovation centers such as CSEM in the field of thin film photovoltaics. Some outstanding achievements in this field are the Millennium Technology Prize awarded to Michael Grätzel of EPFL in June 2010 for the development of dye-sensitized solar cells that now bear his name and are being introduced to the market. Furthermore, Switzerland holds a series of world records in energy conversion efficiency of novel flexible inorganic CIGS solar cells developed at Empa.

Apart from producing electricity, another way of utilizing solar energy is to transform it into chemical energy carriers such as hydrogen. In special solar reactors that concentrate solar energy up to 5000-fold and thus reach temperatures of up to 2000 degrees Celsius, PSI researchers have succeeded in splitting zinc oxide in zinc and oxygen. In a second step, zinc reacts with water to produce hydrogen – and zinc oxide, which is then re-used to "fire" the solar reactor. Their colleagues at Empa are currently exploring new ways of storing hydrogen with novel, "complex" hydrides. These solid materials can soak up hydrogen gas like a sponge and achieve energy densities similar to gasoline.

Even more "elegant" is the idea of synthetic fuel - using solar energy along with water and carbon dioxide to produce liquid hydrocarbon fuels similar to the well-known gasoline. Researchers from ETH Zurich and PSI have recently succeeded in thermochemically splitting water and carbon dioxide to yield hydrogen and carbon monoxide (known as syngas, the precursor of synthetic fuels). Thus, the greenhouse gas is re-used to produce familiar chemical energy carriers, thereby closing the carbon cycle.

Processes with a need for improvement: energy storage and transport …

With solar and wind parks flourishing, the million dollar question is: how do we store and transport all this electric energy? As for transport the buzzword is smart grid, a power grid consisting of a mix of traditional power plants and numerous small, partially remote power plants powered by wind and sun. All these will have to be coordinated, thus increasing the requirements on communication and control systems. Researchers at the ETH Zurich are sketching out scenarios for the power grid of the future and developing the necessary hardware to transform existing lines to high voltage direct current lines capable of transmitting large amounts of electricity over long distances, ideally loss-free.

When it comes to energy storage, one obvious answer is high-performance batteries, which will have to be supplied in increasing numbers if the switch to e-mobility is to become reality. Current battery types are too heavy and have severe limitations in storage capacity. To develop materials and components for new types of batteries with higher energy densities, researchers from the ETH Zurich, EPFL, Empa and PSI have joined forces by establishing new professorships and forging networks with industry.

… as well as energy efficiency, e.g. in the mobility sector

Once renewable energy in sufficient amounts and car batteries offering a satisfactory range are available, e-mobility can take off. Hybrid concepts, combining an electric motor with an internal combustion engine to increase overall efficiency abound, one example being the "Pegasus" hybrid sportster, developed by students from the ETH Zurich and the Lucerne University of Applied Sciences and Arts for the 2009 "Formula Hybrid" competition. In the endurance race over 50 km, it proved to be the most energy efficient vehicle, using only about 0.5 liters of fuel and 4 kWh of electrical energy. A different type of hybrid is the ETH Zurich's pneumatic hybrid engine, which sports a 30 per cent lower fuel consumption compared to conventional gasoline engines with the same power. The concept has received the Watt d'Or Award 2010 by the Swiss Federal Office of Energy and the KPMG Inspiration Grant.

Another way of reducing carbon dioxide emissions is alternative fuels such as methane, available from both fossil sources (as natural gas) or from biogenic sources (as biogas) or hydrogen. One major advantage of methane compared to diesel or gasoline is its higher hydrogen content, resulting in about 25 per cent less carbon dioxide per unit amount of energy.

In the course of the "CLEVER" project researchers at Empa and the ETH Zurich are currently developing a downsized/turbocharged compressed natural gas (CNG) electric hybrid powertrain, which will emit 40 per cent less carbon dioxide compared to a conventional gasoline vehicle of similar performance.

A dream come true: vehicles without pollution

And the next step, the near Zero Emission Vehicle (nZEV), is already in the making. Since combustion also generates other pollutants than carbon dioxide nZEV is equipped with a novel catalytic converter, optimized for CNG engines at Empa. In initial trials, this converter, which requires three times less noble metals than conventional ones, has reduced noxious emissions to almost zero.

That is exactly the promise of hydrogen-driven fuel cells – provided that hydrogen is produced with renewable energy as in the solar reactors mentioned above. Currently tested under real world conditions in several Swiss cities to demonstrate the feasibility of hydrogen-based mobility, the hydrogen-driven municipal vehicle (hy.muve) is a street sweeper developed by Empa and PSI together with industry partners. hy.muve has been shown to consume only half as much energy as a comparable diesel vehicle.

Main energy guzzlers in Switzerland: buildings

With almost 50 per cent of the final energy consumption, Swiss buildings offer huge leverage for energy efficiency, especially the refurbishment of existing buildings. In the "Retrofit" project, researchers at Empa, ETH Zurich, EPFL, PSI, the Universities of Applied Sciences of Northwestern Switzerland and of Central Switzerland are developing refurbishment packages, e.g. by standardization and prefabrication of components, which increase the energy efficiency of existing buildings by a factor of 5 to 10. A number of apartment blocks have already been retrofitted in this way.

Noteworthy components are, for instance, high performance insulation materials such as aerogels and vacuum insulation panels, currently developed at Empa. The insulating effect of these materials is up to 4-fold that of their conventional counterparts and, therefore, allows much thinner and thus much more universally applicable insulation layers. Vacuum is also a key word for glazing systems. The challenge is to attain an air-tight sealing between frame and glass pane. Empa researchers have recently patented a new technique using solder to achieve insulation efficiencies twice as high as with state-of-the-art triple glazing.

Creating value from what is usually wasted: the output side

No matter how efficient combustion engines will ever be – a better part of the energy they generate is lost as waste heat. Thermoelectric generators (TEGs) can transform temperature differences into electricity. If used in cars, for instance on the (hot) exhaust, TEGs could replace other power generators to operate heating, AC or lighting – and reduce fuel consumption by up to 10 per cent. This concept by an ETH Zurich spin-off has recently been awarded the de Vigier prize and the swisselectric research award.

Converting scrap into gold – i.e. organic waste from industry and agriculture into energy – is also the idea behind the biogas research activities at ZHAW. Biomass waste in form of cellulose substrates is pre-treated chemically, physically and enzymatically to facilitate fermentation and thus increase biogas yield. As a by-product, organic fertilizer is produced to close environmental nutrient cycles.

The classical approach: cleaning up afterwards

But even with the best technical solutions at hand not everything we discard can be reused or recycled; waste water, for one, "only" needs to be purified. This is one of the focus areas at the Swiss Federal Institute of Aquatic Science and Technology (Eawag). Researchers there develop new methods to remove, among other things, man-made micropollutants such as hormones, chemicals and drugs from waste water using ozone, as as shown in 2009 during a pilot project in a waste water treatment plant near Zurich. Another Eawag method on its way to the market is a bacterial process to remove more than 90 per cent of the nitrogen, a main culprit for the eutrophication of waters, cutting into half the operating expenses for this treatment step.

But before cleaning and rehabilitation of aquatic ecosystems can occur, surveillance is crucial. CSEM is coordinating the European "MOBESENS" project to monitor key water quality parameters such as metal and ion concentration and pH, including as Swiss partners the University of Geneva and the EPFL. Today, water quality measurements are performed manually; in contrast, MOBESENS proposes to provide a cost-effective, modular and scalable wireless solution for coastal waters, lakes and rivers. The low-power sensor network gathers time and location stamped data samples and automatically enters them into the European Shared Environmental Information System for analysis.

If you can neither recycle nor clean up something, contemplate the last resort – bury it. Carbon dioxide capture and storage intends to do just that with the most prominent greenhouse gas, removing it from our atmosphere, thereby counteracting global warming. An interesting approach currently pursued at the ETH Zurich is storage by mineral carbonation. Carbon dioxide reacts with widely available magnesium or calcium silicates to form the respective carbonates – a safe and enduring carbon dioxide sink.

Michael Hagmann
Empa

Energy storage: Rechargeable batteries, capacitors and hydrogen technologies

With the increasing use of intermittently available and renewable energy sources and in view of the expected electrification of larger segments of the transport sector, the availability of stationary and mobile energy storage devices with improved efficiency becomes a crucial element in the energy network and supply chain.

Power and energy requirements of electrical applications can vary significantly. There are various devices combining high power demand with a low energy requirement, such as the tilt angle control of tilting trains. For this type of application, double-layer capacitors are an adequate technical solution. By contrast, the high energy requirement and modest power demand of devices such as electrical bicycles can be met by batteries. Furthermore, seasonal variations of renewable energy supply for an off-grid building automation system can be leveled out, e.g. by the use of hydrogen storage systems.

Electrochemical double layer capacitors

High surface area carbon materials, e.g. carbon nanotubes, are promising electrode materials for electrochemical double-layer capacitors (EDLC). Research at the PSI demonstrated the potential of single-walled carbon nanotubes (SWCNTs) to improve the power of EDLCs while maintaining energy density. This can be explained by the significantly reduced electrical resistance of SWCNT-based electrodes and the expected low degradation tendency of the surface of SWCNTs. Applications for such EDLCs are being investigated at the EPFL as well as at the Lucerne University of Applied Sciences and Arts in Horw.

Exploring new material combinations for lithium-ion batteries

At several Swiss research institutes, novel material combinations are being explored to improve the performance of lithium-ion batteries. Apart from improving the energy and power density of these batteries, minimising degradation processes is a key issue. At PSI, graphitic carbon is tested as a conductive additive to the low-conducting active materials in positive electrodes. In addition, PSI assesses the combination of the electrode materials and the separator to form a working cell. Safety and reliability aspects of lithium-ion batteries are examined at Empa

Hydrogen as energy-carrier for long term energy storage

There is a variety of approaches for producing hydrogen as an energy-carrier for storage applications. Suitable technologies to produce hydrogen are being developed at Empa, EPFL, ETH Zurich, PSI and the University of Fribourg. PSI and ETHZ, for example, are exploring the use of solar-driven high-temperature chemistry, which allows to produce not only hydrogen but other chemical substances as well.

Apart from the production, the long-term storage of the hydrogen is among the crucial issues in energy management. Empa and EPFL are examining new approaches for storing hydrogen in hydrides or having it bound in molecular liquids. In addition, EPFL develops improved materials to store pressurized gaseous hydrogen.

The conversion to electrical energy of the chemical energy stored in hydrogen is done most efficiently with fuel cells such as low-temperature or high temperature fuel cells. The use of low-temperature fuel cells for mobile applications is investigated at EMPA, PSI as well as at the Berne University of Applied Sciences in Biel and at the University of Applied Sciences Western Switzerland in Yverdon. High-temperature fuel cells are explored at ETH Zurich, Empa and EPFL, mainly with a view to stationary heat and power production.

Philipp Dietrich and Alexander Wokaun
Paul Scherrer Institute PSI

Technology transfer and the clean technology challenge

About CSEM
CSEM is a private research and development center specializing in microtechnology, nanotechnology, microelectronics, system engineering and communications technologies. It offers its customers and industry partners tailor-made innovative solutions based on its knowledge of the market and available technological expertise derived from applied research.

Further Information
More information about CSEM is available at:
www.csem.ch

It is generally assumed that we will soon reach "peak oil", the point in time when the maximum rate of global oil production is reached. Experts predict that easily accessible – i.e. cheap – oil resources are halfway exploited by now, which leaves mankind about 50 years – or two generations – to develop novel, therefore technically unproven, breakthrough technologies.

There is widespread agreement that clean technologies will make a significant contribution to achieve these breakthroughs. However, unless silver bullet solutions are found, we will need a broad portfolio of energy technologies, comprising hydroelectric, wind, solar and bio-fuel power, as well as energy-saving and energy distribution technologies such as batteries, hydrogen storage, high-voltage long distance energy transmission and smart metering.

The massive technological challenges call for an excellent communication path from the academic world to business and society in order to convert scientific results into technological advances. To reach this goal various requirements have to be met: excellent applied research, close links to industry, a number of complementary routes to turn research results into business ideas, lots of smart people – not to mention sufficient resources to fund all these activities.

The public-private partnership

Public-private partnerships play a crucial role in this context. The public side in Switzerland is based on an excellent educational system as the country places a high value on the delivery of good-quality education and boasts a great many higher education opportunities. It is one of the world's leading investors in education per capita.

Comprehensive funding of basic research at universities and of applied research at universities of applied sciences and other research organizations traditionally has been the responsibility of public authorities in Switzerland. However, improvements in policies and funding schemes are still likely to trigger economic incentives in the private sector, ideally kick-starting market pull. A knowledge and technology transfer process that is both effective and efficient therefore requires a fast transfer of know-how from research to end-users, in particular in fields such as new energy technologies.

The private side of the technology transfer process, on the other hand, assumes substantial financial, technical and operational risks to be involved in the project. These risks are then mitigated by the advance investments made by the public authorities described above.

The entire technology transfer process needs to take place both within and between national and international partnerships of different technology providers along the value chain. Enabling these efforts Switzerland will maintain and extend further its clean technology leadership. Owing to the close collaboration between governmental research departments and industry, the technology transfer process has a direct impact on Swiss industry performance: it provides the best technology solutions available to industry and allows fast commercialization of advanced inventions and technology leaps.

The importance of start-up companies

Switzerland is among the global leaders with respect to innovations and patents per capita – as shown, for example, by the recent 2010 Innovation Union Scoreboard. It is, however, somewhat less successful in transferring these innovations into products or start-up com-

panies. Within the scope of a successful technology transfer process, entrepreneurial training for the technology experts and start-up founders involved is a key factor. Furthermore, favourable funding conditions, i.e. in respect of seed-money and venture capital, are needed in addition to a solid legal setting e.g. with regard to intellectual property rights.

Major research centers such as CSEM, EMPA, and PSI, as well as academic institutions (EPFL, ETHZ, universities, universities of applied sciences) create today a significant number of start-ups, supporting the country's economic growth through the creation of numerous high value, high qualification jobs. A successful example in the cleantech domain is the CSEM start-up Adamant Technologies, which was created in 2005. This company is active in the development of diamond coatings and water treatment, water sensing and monitoring and metrology solutions using diamond electrodes.

The multiple benefits of clustering

A cluster is a partnership between a range of regionally based or focussed organizations dealing with a specific technology. Clustering of academia, R&D, industry and investment funds facilitates communication, interaction, cross-fertilization of ideas, capabilities, and suitable processes for generating products. Clustering can occur on a local, national or international level (see p.43). Among a cleantech cluster's main goals are the promotion of innovation and investment.

In Switzerland, several regional clusters have formed, such as Cleantech Fribourg and Cleantech Alps (see p.44). Partnerships with complementary R&D organizations allow broadening the technology spectrum and therefore increase the relevance for and appeal to industrial clients and investors. On a national level, Osec is leading the "Cleantech-Switzerland" initiative for small and medium size enterprises (see p.43). Similarly, direct cooperation with industry is the idea behind a number of strategic alliances. For example, Empa has set up a strategic partnership with Hexis, aiming to establish the solid oxide fuel cell technology for combined heat and power generation in buildings (see p. 34). Sustainable building technologies, including water management, are at the core of the NEST project, a joint initiative of Empa, ETH Zurich, EPFL and Eawag. The "Living and Building Lab of the Future" to be constructed on the Empa-Eawag campus is conceived as a modular, "plug-and-play" R&D platform. NEST is specifically tailored to the requirements of industry partners to allow the testing, demonstration and optimization of novel materials and components and innovative systems under real-world conditions.

As an example on the international level, CSEM has joined forces with the French Commission for Atomic Energy CEA, the German Fraunhofer Group for Microelectronics and VTT Technical Research Centre of Finland to form the Heterogeneous Technology Alliance (HTA). The HTA helps to convert results from microtechnology and nanotechnology research into real products and services. Addressing energy management issues is a crucial topic. The major areas where HTA members' technological goals converge are smart systems, 3-D integration, ultra-low-power electronics, smart high-power electronics, energy conversion, energy-efficient buildings, and efficient solid-state lighting. HTA members have also created a commercial unit, a company called "4-Labs", to exploit potential synergies and increase the acquisition of development projects through direct partnership with industry.

Carsten Winnewisser
CSEM Neuchâtel/Zurich/Alpnach/Basel/Landquart

Protecting intellectual property in the cleantech field

The Swiss Federal Institute of Intellectual Property
The Swiss Federal Institute of Intellectual Property is commissioned to inform scientists and engineers as well as companies about the various aspects of intellectual property. In this context, the Institute offers the following services:

- training and special courses for academia and the corporate world **www.ige.ch/en/training/training.html**
- assisted patent searches for scientists and engineers in both industry and academia **www.ige.ch/en/searches/patents/assisted-patent-search.html**
- tailored searches for companies, professionals in the intellectual property domain and individuals **www.ip-search.ch**

As in other high-tech industry sectors, patents play an important role in the cleantech field to protect innovations and ensure market leadership. The patenting activities of companies and research institutions in Switzerland increased during each of the last two years on average by about 25 per cent.

The market for clean technologies has grown considerably due to a number of direct and indirect factors. Global climate change concerns, volatile fossil fuel prices and supply, the accelerated exploitation of natural resources, and a recent increase in funding for alternative energies, among other factors, have put the focus on cleantech industry. The increasing importance of cleantech is reflected in the significant surge in research and development and, correspondingly, in growing patenting activities. For example, the number of cleantech-related patents hit record levels during the first quarter of 2010[1] in the United States.

The growing importance of the cleantech field is also reflected in a specific classification scheme for clean energy technologies that was recently established by the European Patent Office (EPA). Assuming that almost all technologies concerned passed through the patent system at some point, information on published patent documents can in principle deliver a fairly complete inventory of these technologies. The new classification scheme therefore helps identify relevant inventions in the field and foster the ongoing development of clean technologies.

Switzerland consistently ranks as one of the world's top economies in terms of environmental concern, largely thanks to its research and development efforts in the generation of renewable and clean energy, energy-efficient buildings, strict waste management and recycling, and sustainable transportation. Switzerland was recently ranked second on the 2010 Environmental Performance Index of Yale University which ranked 163 countries on 25 performance indicators tracked across ten policy categories and covering both environmental public health and ecosystem vitality.

In Switzerland as elsewhere the number of patents issued for cleantech inventions is still only a small fraction of all patent documents published, e.g., clean energy patents account for approx. 1 per cent. However, the number of patent documents listing at least one Swiss applicant in this technology sector is growing fast, i.e. at a pace of about 25-30 per cent per year. In the area of technologies related to clean energy generation, transmission and distribution, Swiss assignees were listed on 330 patent documents per million of its population in 2009. This compares with German assignees on 240 and US assignees on 64 published patent documents.

Researchers from both university and industry have been challenged by the fast pace of development in the cleantech field. They often struggle with technical information made available in more than 70 million patent documents, which are thought to contain up to 80 per cent of all technical know-how in certain technical fields. In order to support them, the Swiss Federal Institute of Intellectual Property offers professional patent information services tailored to the needs of academia and industry, thereby helping to fill the knowledge gap.

Heinz Müller
Swiss Federal Institute of Intellectual Property

[1] Clean Energy Patent Growth Index, Heslin Rothenberg Farley & Mesiti P.C.

Cleantech in Switzerland – its strengths and potential

swisscleantech
With transparent general conditions and cluster activities, cleantech can unfold its economic and ecological potential and secure living standards for the long term. Switzerland's position is outstanding in this regard.

In order to achieve the goals set and to allow Switzerland to retain its position at the cutting edge of cleantech in the long term, an optimal promotion of innovations as well as stakeholder networking across all sectors are of great importance. Thirty concrete recommended actions with regard to this are provided in "Cleantech Strategy Switzerland" by swisscleantech.

Further Information
Further information about Swiss Cleantech is available at:
www.swisscleantech.ch

Further information about the Cleantech Framework is available at:
www.plus.ffgs.org

Switzerland has been fostering cleantech for many years, and as such is extremely well-positioned to take advantage of the growing global market. There are three main ways in which the country's position as a leading location for cleantech will be further strengthened: by research coupled with companies that consistently focus on the cleantech field, by coordinating cluster activities and by setting a transparent framework for future development.

Ecological challenges show that a transition towards a sustainable economy is essential at a global level. Cleantech is making a crucial contribution in this regard and, as a result, a reorientation towards numerous value-added activities is taking place. Cleantech is, in fact, more than renewable energy. It is actually a key factor in resource-optimized and low-emission economic management, and as such is important for many industries and a most diverse universe of business activities.

In comparison to other countries, Switzerland offers excellent conditions for participation in global cleantech development. An important role is played by the formation and reinforcement of clusters.

Current situation and future potential
To make the most out of the development of the cleantech field, to tap existing potential, as well as to implement the changes required, several key conditions have to be met. These are: a high level of education and knowledge, an awareness of quality, investment, and enthusiasm for innovation.

Switzerland is not only one of the world's most innovative and competitive national economies, but, due to its high quality of life, also manages to attract outstanding talent to its knowledge-intensive sectors.[1] The Swiss also have a strong awareness of sustainability due to their familiarity with environmental protection[2], recycling, and public transport. In addition, Swiss universities are among the world's leading research and educational institutions, and their excellent vocational education programs enable new technologies to be put into practice.[3]

The study, "Switzerland: The Innovation Landscape" by swisscleantech, the business association for cleantech companies in Switzerland, shows that the innovation potential in Switzerland can be even better exploited.[4] A survey of various venture capital firms, start-ups, and public authorities revealed that interest in cleantech products and services is very high in Switzerland, and that there is an additional demand for seed capital. In order to better meet the demand for this main source of funding for innovations, clusters – which connect investors and companies – are particularly important.

Clusters as pioneers
Clusters can take various forms. With classical geographical clusters, location promotion plays a central role by optimally connecting companies, research institutions, and investors at regional level. Because of the large concentration of high-performing research institutions and companies in the field of cleantech, as well as because of Switzerland's federal structure, cleantech activities are linked together in various regions in order to form and strengthen powerful clusters. One example of this type of network is CleantechAlps, which aims to promote companies and research institutions active in clean technologies and based in the western part of Switzerland (see p.44). Alongside the formation of regional clusters, the creation of national innovation parks at government level is also planned.[5] Swisscleantech's involvement is to ensure that the cleantech sector is provided with an appropriate focus.

Secondly, cleantech clusters form outwards through the organizational networking of companies in associations and their external representation. According to a study in Denmark, three factors are crucial in making sustainable economies possible: firstly, a stable, well-informed and sufficiently-financed government (state capacity); secondly, the ability to bundle stakeholders with similar interests under a collective umbrella organisation (associative capacity); and thirdly, information exchange as well as cooperation between the state and interest groups (corporatist deliberation).[6]

swisscleantech plays an important role at the intersection between state, research, business and the public: public authorities and political decision makers have a competent point of contact for cleantech issues, and the networking of cleantech companies in Switzerland accelerates the learning curve and growth of such companies. To further improve networking of the relevant stakeholders, i.e. associations, universities, governmental institutions, and investors, swisscleantech formed so-called focus groups on the topics of "Mobility and Logistics", "Innovation and Investment" as well as "Buildings and Urban Planning." The latter was in cooperation with the Minergie Association, which campaigns for the construction of sustainable buildings. In addition, stakeholders - particularly those within the field of export - can take advantage of the "Green Embassy" flagship project in Washington[7] as well as the development of an international solution with regard to building standards through the Foundation for Global Sustainability.[8]

Thirdly, clusters can form - regardless of their location - through virtual networks with the help of electronic platforms, databases, and services, all of which structure and supply information on companies and activities in a technology or industrial sector. For efficient virtual networking, the categorization of existing and planned cleantech activities is of utmost importance. Which is why swisscleantech has used the so-called Cleantech Framework to classify cleantech activities across all sectors for the first time ever by building a database and information service, which serves to structure information on researchers and companies and then correlates them with each other. In this way, stakeholders in the Cleantech sector can be provided with information and linked in a targeted way. As a virtual cluster, the Cleantech Framework will make it possible to provide information on existing and potential cleantech activities to interested parties. Cleantech will also become quantifiable, locatable and therefore tangible – all important factors in shaping suitable conditions for sustainable market economies.

Nick Beglinger, Christina Braun, and Yannic Steffan
swisscleantech

[1] Mercer, Quality of Living Ranking 2010
[2] Yale University, Environmental Performance Index
[3] Conference of Rectors of Swiss Universities, www.universityrankings.ch
[4] Foundation for Global Sustainability, The Innovation Landscape – An Analysis from the Cleantech Perspective, www.swisscleantech.ch/innovation (available in German only)
[5] Federal Act on the Promotion of Research and Innovation (TK)
[6] C. Daugbjerg & D. Halpin, Generating Policy Capacity in Emerging Green Industries, Journal of Environmental Policy & Planning 12(2) 141-157, 2010
[7] www.eda.admin.ch/eda/en/home/reps/nameri/vusa/wasemb/theemb/chresi.html
[8] Foundation for Global Sustainability, www.ffgs.org

Switzerland as a platform for cleantech companies

Problems stemming from changes in the climate and environment concern us all. That is why collaboration both on a global and a domestic level is important for the cleantech sector. For companies to be successful and achieving, two key factors are needed: an attractive business environment, which supports corporate growth and development and solid financial markets for the supply of capital.

In Switzerland, the fruitful interaction of many mutually supportive factors has resulted in a strong financial hub with optimal overall business conditions. Location advantages such as easy access to authorities, innovation power and competitiveness as well as the availability of highly qualified personnel all have a positive impact on the financial center, which conversely impacts positively on the location thanks to global interconnectedness and a well-established capital market.

Laying the foundation: strong location-specific factors

With a whole series of strong location factors in place, Switzerland offers optimal overall conditions for cleantech companies. This is emphasized by a study of the World Energy Council in which Switzerland was ranked first in a comparison of countries in regard to their energy and climate policies: when it comes to sustainable practices, Switzerland is top notch.[1] The sensitivity of its population to the notions of sustainability and environmental awareness are illustrated in the country's high standard of living, environmental quality and low levels of pollution.

Moreover, Switzerland counts among the world's leading nations with regard to innovation power and infrastructure. As regards global competitiveness Switzerland is ranked among the top countries each year.[2] A key factor, among others, is the strong innovation power of companies based in this country.

Further decisive factors for Switzerland's attractiveness include the country's outstanding educational system and the long tradition of Swiss scientists and engineers in technologies relevant to the environment. Furthermore, Switzerland is ideal for international business because of the high quality and reliability of its infrastructure, its political and legal stability, innovation-driven economy, market-consistent regulatory standards, and its liberal labor laws. Last but not least, the country's competitive tax levels, its quality of living, and its openness toward the rest of the world all contribute to Switzerland's excellent reputation as an ideal high-technology location.

Solid financial center driving growth

The Swiss financial center is very attractive for companies in search of capital both in Switzerland and abroad. It is well structured, closely interconnected and yet, geared to international standards. Domestic banks are known to have strong funding and placing power.

The Swiss financial marketplace in numbers:[3]

- International investor base and leading position in cross border private banking worldwide
- Total amount of assets under management: approx. CHF 4,382 billion
- Foreign clients: 54 per cent
- Institutional investors: 67 per cent
- Invested in stocks and funds: 67 per cent
- A leading financial hub for equity-investing institutions

A healthy financial center needs an efficient, well-functioning capital market. In Switzerland, the products and services of SIX Swiss Exchange make a significant contribution in this regard.

For Swiss and foreign companies, SIX Swiss Exchange is the gateway to the international and domestic capital market. A public offering and listing of securities on SIX Swiss Exchange affords a company access to a highly experienced and financially potent circle of international investors. Each firm listed on SIX Swiss Exchange benefits from a high degree of visibility and recognition amongst global investors, analysts and the media.

Knowledgeable investors

Investors active in Switzerland who invest in securities listed on SIX Swiss Exchange generally have an international background. Based on the Swiss economic structure the cleantech sector enjoys a high level of attention in the investing community. Swiss investors are among the pioneers in this sector. As early as 1994 the Swiss Bank Sarasin launched the first ecologically effective fund worldwide. A wide range of cleantech investors are active within and outside the borders of Switzerland, among them Credit Suisse, Emerald Ventures, Good Energies, Mountain Cleantech, Pictet, SAM (Sustainable Asset Management), UBS, Unigestion, and ZKB. Switzerland is a global financial hub for investments in this sector.

Andrea von Bartenwerffer
SIX Swiss Exchange

[1] World Energy Council, Pursuing sustainability: 2010 Assessment of country energy and climate policies, September 2010
[2] World Economic Forum, The Global Competitiveness Report 2010–2011
[3] Swiss National Bank, Monthly Statistics Bulletin, November 2010

Economic and location promotion in Switzerland

Further Information
More detailed information is available at:
www.invest-in-switzerland.com

As one of the most attractive business locations worldwide offering numerous strategic advantages, Switzerland came out on top in the Global Competitiveness Report 2010-2011. Home to many of the world's leading cleantech companies and ranking number two in the Yale Environmental Performance Index 2010, Switzerland provides the best prerequisites for forward-looking research, production and service companies in the cleantech sector.

Economic and location promotion are an integral part of Switzerland's economic policy. Various measures implemented at the local, regional, and national level support the economic activities of local Swiss companies and help foreign companies extend their activities to Switzerland.

The number of companies that have moved their European headquarters to Switzerland has risen in recent years. Since 2003, 269 headquarters have been relocated to Switzerland including major corporate names such as IBM, General Motors, Kraft Foods, eBay, and Google.

Switzerland. Trade & Investment Promotion
At the federal level, Osec, the competence center for Swiss foreign trade promotion was commissioned by the Swiss State Secretariat for Economic Affairs with its program "Switzerland. Trade & Investment Promotion" at the beginning of 2008. Osec is in charge of the operative responsibility for the promotion of Switzerland as a prime business location, in addition to export, import, and investment promotion tasks.

Within this program, Osec organizes and coordinates various activities to attract foreign investment in Switzerland, thereby acting as a door opener for the country and its authorities. In close collaboration with partners from different regions and cantons and from the private sector, the program assists foreign companies in planning for:

- the selection of an ideal business location in Switzerland
- making contacts with regional and cantonal investment offices
- legal and administrative requirements
- collaboration with research centers and universities
- the Swiss tax system and incentives for investors
- partnering with Swiss firms in a specific area of business
- residence and work permits

Switzerland. Trade & Investment Promotion supports companies at any time in their fact-finding efforts and investment projects.

In addition to its performance mandate concerning Switzerland. Trade & Investment Promotion, Osec is involved in the development of the Cleantech Switzerland export platform, which aims to provide small companies at the cutting edge of clean energy innovation and environmental leadership with easier access to export markets (see p.43).

Hans Jörg Jegge
Osec

Exploring the economics behind energy efficient technologies

The global long-term challenge of mitigating climate change and building a sustainable energy future calls for a better understanding of the economic mechanisms behind the generation and diffusion of energy efficient technologies. A comprehensive survey undertaken among Swiss companies by the ETH Zurich's KOF Swiss Economic Institute provides new insights.

The last decades have seen a growing consensus that today's patterns of energy use are highly unsustainable. Depletion of non-renewable energy sources threatens to cause substantially higher energy prices as well as decreasing levels of extraction in the foreseeable future, and the adverse effects on the global climate of carbon dioxide released by burning of fossil fuels are widely acknowledged by the scientific and political community. Understanding the patterns of innovation and diffusion of technologies that are capable of reducing our reliance on non-renewable energy carriers will therefore become a key factor for decision makers both in the corporate and political world.

At the corporate level, little data and subsequent analysis have been available so far. Such an effort is, however, represented by the KOF Swiss Economic Institute's 2009 Energy Technology Survey, which was carried out with financial support from the Swiss Federal Office of Energy. The goal was to gather enterprise level information related to corporate adoption and innovation performance regarding a number of relevant energy technologies. Building on this unique data source, econometric exercises were conducted in order to shed light on the determinants of both innovation and adoption of energy efficient technologies. This was then followed by an analysis assessing the effectiveness of policy measures implemented to foster the adoption of such technologies.

The Survey

KOF was able to build on its experience and existing address base for conducting its survey. The KOF Enterprise Panel – a continuously maintained and updated address base constituting a representative sample of manufacturing and service companies – was used in order to contact approximately 6,000 company representatives by means of a postal survey.[1] With 2,306 valid questionnaires, a response rate of 39.7 per cent was achieved, which may be deemed reasonably high, given the complex nature of the topic and questionnaire. Roughly half of the manufacturing companies and slightly fewer (40 per cent) service providers were found to be users of some kind of energy efficient technology. Innovation in such technologies occurs in a much smaller proportion (7.6 percent) of companies, which for the largest part can be found in the machinery, electrical engineering and electronics sectors. See pages 47–49 for a compilation of further descriptive results.

Subsequent Analysis

In the subsequent econometric analysis, the following findings emerged: Individual companies' characteristics such as corporate size, R&D activities and environmental awareness significantly affect the probability of adopting some kind of energy efficient technology. Moreover, it was possible to detect the reinforcing effects of diffusion at the industry level (the so-called epidemic effects). With respect to corporate innovation activities in these technologies human capital and future demand expectations were identified as important drivers, amongst others. Innovators in energy efficiency, however, are less market-oriented than innovators in other technology fields. Finally, recipients of funding from certain

support schemes[2] were found to exhibit better performance in terms of energy efficient technology adoption than their counterparts in the respective control group, a finding which provides justification for such policy measures.

Marius Ley and Martin Wörter
KOF Swiss Economic Institute

[1] The population was restricted to companies with at least five (full-time equivalent) employees, active predominantly in the private sector (therefore excluding activities such as education, health and government).
[2] The sponsoring institutions considered in this analysis are a number of Swiss cantons and municipalities as well as the private sector based Climate Cent Foundation (Stiftung Klimarappen).

Which future for photovoltaics in Switzerland?

Further Information
More detailed information about the Photovoltaics and Thin Film Electronics Laboratory is available at:
pvlab.epfl.ch

"The problem of energy will become the key problem of the 21st century and Switzerland has a good chance to play a role in solving the technological problems involved. The country is in a very good starting position for PV technologies and in that sense it is really important that all actors in Switzerland, such as the government, the academic institutions, and the funding agencies, are aware of how important this topic is for the future of our society in general. They have to shift and allocate as many resources as possible to this topic. It is a strong message to develop novel and improve existing energy sources, develop cost effective ways to store or save energy and improve the management of energy. All the measures that point towards more sustainability will be necessary for a better world in fifty years."

Christophe Ballif is director of the Photovoltaics and Thin Film Electronics Laboratory at the Institute of Microengineering (IMT, EPFL) in Neuchâtel. In the following interview, he presents an overview of ongoing research on photovoltaics in Switzerland and its perspectives.

Mr. Ballif, how has Switzerland positioned itself in the photovoltaic (PV) domain?
Currently, Switzerland is already competitive in the PV domain in terms of the production of equipment and in the development of new solutions for measurement systems or components such as inverters or electrical connectors. This is well in line with the industrial tradition of the country relative to the commercialization and export of production tools such as the machine-tools of the past. Of course we need to ensure that we will remain competitive in the long term, coming up with further technological innovation and, since PV develops worldwide, trying to take an even larger share of the market.

The actions required are, first and foremost, a much stronger support for high-level research and development. Secondly, we need to provide the relevant industries with the possibility to collaborate with the research institutes and to access their results. Finally, the development of a domestic market for PV modules in Switzerland would create a strong stimulation motivating these industries to develop better equipment and solutions.

In terms of producing PV modules, we have several module producers in Switzerland, which have to find their own niche market where they can compete with Asian or German products. Indeed, you need to stand out with your products, such as light weight, flexible PV membrane or special architectural solutions, or show your competitive edge with, for example, a new generation of high efficiency modules. I am confident that we can be competitive with Chinese companies if we choose the right technology.

What position has Swiss research in the photovoltaic domain worldwide?
In terms of research, Switzerland has quite an opportunity. Even though it is a rather small country, it has various excellent research institutes, including the EPFL in Lausanne and Neuchâtel and Empa in Dübendorf. Their research covers the major categories of devices that are now on the market, particularly thin film devices.

The group of Ayodhya N. Tiwari is active in flexible so-called CIGS solar cells and cadmium telluride PV. The group of Frank Nüesch is active in organic PV, while Michael Grätzel pioneered dye-based PV cells. Our group in Neuchâtel focuses on silicon based devices, with high efficiency crystalline cells and low cost thin film silicon modules. All these groups are well positioned internationally. A lot of know-how is available and, in addition to that, several universities of applied sciences and several industrial research laboratories, including companies such as Oerlikon Solar, have specialties well placed on the market.

To which extent does Swiss research cooperate with industry?
Several companies are making a big effort in PV R&D. Besides Oerlikon, you'll find companies such as Von Roll or Meyer Burger (see p.30). But you'll also find Roth & Rau, a German company that has opened a R&D subsidiary in Neuchâtel, or DuPont that has established a PV application research laboratory in Meyrin/Geneva. Most of these companies have direct links to or contracts with academic laboratories.

How do you contribute to the cleantech field?
Our laboratory offers contributions in various fields. Firstly, we create know-how for applicable technologies and transfer this know-how either to the relevant industries or other actors.

Secondly, we play a very important role in educating people in the PV industries. Some have already studied or worked at IMT. Right now we also propose a special education program relating to our technologies that are now implemented in many production lines worldwide. We regularly host people from companies such as Bosch, Oerlikon and others that come here for a one-week visit to better understand the scientific basis of the devices they are producing. And of course we want to create economic value: we want to create start-ups and jobs; we want to help companies to create new business segments with our core competencies.

In Switzerland, we have fantastic tooling industries and equipment makers. They do not automatically have the know-how but the capacity to build innovative tools for the cleantech field. We have many projects with companies such as Solneva, which develops tools for laser based applications, and Essemsolar, which develops new screen printing systems. We are linked to about 15 companies in Switzerland alone, helping them to put better technology solutions on the market.

We heard about a stronger collaboration with CSEM. What can you tell us about that?
Rather than to speak about collaboration, I would say we are developing part of our activities along with CSEM. Our laboratory, even though it has grown considerably over the last years reaching now about 60 employees, has remained an academic service. Considering the bright future for solar energy it is important to develop technologies at a more commercial level, more oriented towards the industry.

We need centers where you have people that stay long enough to develop very strong activities and master stable processes. This is not always the case in an academic environment where you have people coming and going. We aim to set up facilities that are closer to the industry and, in that context, CSEM is an excellent platform with a mission that has been underestimated in Switzerland.

What distinguishes CSEM from other institutions?
Creating a strong link between research and its applications has not been so much in the focus of Swiss policymakers. But CSEM has managed to act as a crucial interface between research and industry. In Switzerland, CSEM is really a key player for the fast transfer of technological innovations to industry. This successful concept can now be applied for the development of the PV field. There are similar centers in other countries in the world, like the Fraunhofer Institutes in Germany or technology centers in Singapore or Taiwan, which are already oriented toward creating economic value. I think Switzerland needs a CSEM or an equivalent service that is five or ten times larger!

(fad,cs)

Christophe Ballif
Christophe Ballif is director of the Photovoltaics and Thin Film Electronics Laboratory at the Institute of Microengineering in Neuchâtel, which has been part of the Swiss Federal Institute of Technology in Lausanne since 2009. The laboratory is active in the fields of thin film silicon, high efficiency heterojunction crystalline cells, and module technology. The laboratory has a strong expertise in technology transfer and industrialization of novel devices.

Sunny times ahead

Further Information
For further information about Meyer Burger please visit:
www.meyerburger.com

Cleantech is mainly associated with innovative products such as solar cells. It is generally less known that these products have to be produced in many complex steps which are technically demanding, but must be cost-effective for the products to remain competitive. Advancing the technical processes required significantly helped increase the competitiveness of solar cells on the energy market. The Swiss company Meyer Burger has made an important contribution to that goal and is today one of the global market leaders in production plants for solar panels.

Silicon is the base material of most solar cells of today. It is usually found in the form of quartz and other more complex silicate minerals. To be available for the production of solar cells, it has to be separated from the other elements. At the end of this process, high purity silicon is obtained in the form of a solid block, which is subsequently cut into thin slices, the so-called wafers. These wafers are treated and processed further to finally become solar cells.

Production of wafers as a crucial cost factor

In light of the high requirements as to the base material and the various steps in the preceding process flow, it does not come as a surprise that the costs for the wafer production largely determine the total costs of solar cells.

Remarkable efforts are being made to bring these costs down. For example, some researchers and companies try to replace silicon with other materials which can be produced more easily and at lower cost.

Meyer Burger has taken a different path. The company has developed cutting machines which allow it to optimize the slicing of silicon blocks into wafers. The machines are able to cut extremely thin wafers and minimize the loss of material during the process. Both the thin slicing and minimal loss of material make a significant contribution to producing as many wafers as possible from a valuable silicon block, thereby effectively lowering the total costs of solar cell production.

Rapid growth

Since the establishment of watch making in Switzerland companies for precision instruments have strongly contributed to economic development. These companies have striven to continuously improve their technology and adapt to the technological and economic demands put forward by their customers in Switzerland and abroad.

Meyer Burger, established in 1953 as a producer of machines for the watch making industry, has throughout its history specialized in cutting machines. Taking advantage of its innovative and sophisticated products the company benefited strongly from the booming solar sector in the last decade. Within a few years, Meyer Burger has grown to become a global market leader for special machines for solar cell production.

One step ahead

Prospects are bright for Meyer Burger to benefit further from the ongoing global trend towards sustainable energy supply although there may be demanding challenges ahead. To cope with technological hurdles and increasing competition the company aims to steadily improve the innovation process and to offer standardized products to customers. By diversification, acquisition of specialized enterprises and strategic partnerships with other innovative companies in the solar field, Meyer Burger has progressed to become one of the leading providers of current production lines in the solar business. It now covers a substantial part of the integrated value-added chain, ranging from cutting wafers, producing individual solar cells and manufacturing solar modules or complete solar systems.

Through clear-sighted focussing on customers' needs and on global trends in the cleantech area Meyer Burger as well as other innovative Swiss companies have managed to benefit from the cleantech boom and stay one step ahead of an increasing number of competitors from other countries. They continue to face bright prospects.

(cs)

The New Monte Rosa Lodge – setting new high-tech standards in an environmentally sensitive mountain area

ETH Zurich and the Swiss Alpine Club (SAC) have built a state-of-the-art alpine lodge that is both sustainable and ecological. This autonomous alpine structure is located at 2883 m above sea level in an intact and highly sensitive nature conservation area on the slope of the Monte Rosa. At 4635 m, this mountain, which is also known as Peak Dufour in honour of one of the founders of the Red Cross, is the highest elevation point in Switzerland.

The timber frame of the mountain lodge was built on a stainless steel and concrete foundation deeply embedded in the rock of the mountain slope (see front page). The wooden structure was digitally optimized and pre-fabricated. Since at 3000 m the air does not carry much humidity, the air inside the lodge is much drier than in any other building at lower elevations. With its shiny aluminium surface, distinctive window ribbon and striking polygon shape, the new lodge resembles a giant rock crystal. Yet, despite its futuristic appearance, it is a harmonious addition to the surrounding alpine landscape.

Since the lodge clings to the edge of a glacier beyond the range of any power lines, it was designed from the beginning to be 90 per cent energy independent, optimizing energy efficiency and keeping carbon dioxide emissions very low. 16 kW_{peak} photovoltaic panels installed on the facade generate electrical energy which is then stored in batteries for later use. The remaining 10 per cent of the lodge's electrical energy needs, especially for peak consumption periods or during unfavourable weather conditions, are covered by a combined heat and power unit running on rapeseed oil. The use of wind energy was considered but did not appear feasible because of the extreme temperature and wind expositions at the building site. The heating system is mainly based on an additional 60 square meters of thermal solar panels installed on the rocks outside of the building. Additionally, the heating system relies on heat recovery from waste air to supply heat during very cold spells, or when only a few people are staying in the lodge. These two systems guarantee a room temperature of at least 15 degrees Celsius in the restaurant and 10 degrees Celsius in the bedrooms. If the lodge rooms are unoccupied, the temperature is reduced to 5 degrees Celsius in order to save energy but prevent frost damage to the building.

The structure also features a unique water storage system: snowmelt from the glaciers is collected during the summer and kept in a 200 cubic meter underground frost-free reservoir for use throughout the year. This is necessary as no usable spring was found in the vicinity of the lodge. The water is filtered and disinfected before being used for cooking and personal hygiene. About 56 per cent of the fresh water is heated mostly through the solar panels to provide warm water for showers and cleaning dishes. Also, domestic wastewater from the kitchen or showers is collected and micro-filtered on a biological basis before being used to flush the toilets. Sewage water is filtered and treated in a biological decomposition system. The cleaned sewage water is then released into the environment and the sludge is stored in bags for removal.

Sophisticated energy management system

Every single system operated by the mountain lodge is environmentally friendly and sustainable. The high degree of energy autarky and controlled water usage largely depends on a sophisticated energy management system, collecting data such as climate information from its own weather station, the number of people using the lodge, and information from the energy as well as water storage systems. The lodge's services engineering is largely based on well-proven equipment with optimized components. Thus, the objective was mainly to

optimally interlink and control all components in a harsh environment and fast changing weather conditions.

The considerable and extensive planning for the new mountain lodge was carried out for more than three years by an ETH Zurich interdisciplinary team comprising professors and students from architecture, engineering and environmental sciences. They worked closely together with outside experts and SAC members to design the five-story, 120-bed mountain lodge. This is a perfect example for the inventiveness of Swiss architects, engineers and scientists in the cleantech area.

Attraction pole

The alpine structure is used by mountaineers and nature lovers from all over the world as a starting point for hiking and climbing expeditions to the nearby mountains and glaciers. Beyond that, this new aesthetic lodge has already become an impressive architectural landmark in the whole alpine region, serving as a research object for ecological and sustainable constructions at high altitudes.

(hm)

The power station in your basement

Decentralized energy supply is expected to play an eminent role in the future. It allows satisfying the energy needs of individual consumers from nearby local sources while minimizing energy loss during transmission. Hexis, a Swiss company based in Winterthur, develops, produces and markets a ground-breaking fuel cell system using combined heat and power units for use in single-family homes and apartment buildings.

Fuel cells efficiently convert chemical energy bound in fuels into electricity, which makes them especially interesting for the decentralized generation and supply of electricity. With rates as high as 90 per cent or even higher if waste heat is reused for heating, the efficiency of fuel cells surpasses by far that of the established energy conversion techniques such as conventional coal plants. What is more, fuel cell based energy supply is also carbon neutral if renewable fuels such as biogas, synthetic gas or even hydrogen are employed.

For its combined heat and power units, Hexis relies on solid oxide fuel cell (SOFC) technology operated at temperatures from 800 to 900 degrees Celsius. To reach the desired power rating, several SOFCs are combined in stacks. Unlike other fuel cell technologies, SOFCs can use not only hydrogen but also biogas or natural gas, allowing the connection of SOFC-based devices to existing natural gas supply lines. This makes SOFCs ideal candidates for combined heat and power stations in individual buildings, especially as they are low-noise and emit extremely low levels of carbon monoxide and nitrogen oxide, respectively.

Strategic partnership between Hexis and Empa

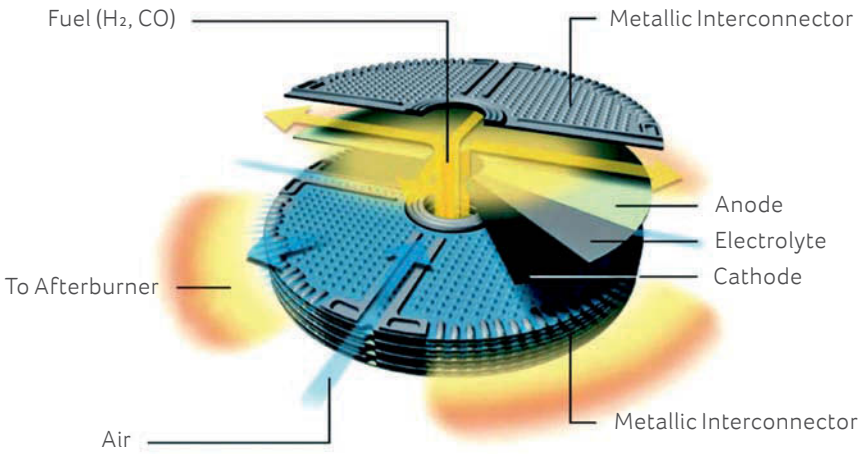
The market for heating units has developed over a long period, and commercially available products are now being optimized in terms of reliability, product life cycle, and costs of acquisition and operation. Thus, the market launch of a fuel cell based device for heating units is a serious challenge. To meet the quality standards in the heating unit sector it requires extensive research and development not only in the fuel cell field but also in the area of system management .

To cope with these challenges, Hexis has entered into a strategic partnership with Empa which has been working on the development of fuel cell materials for many years as well and gained considerable experience from testing thermal and mechanical loads under the extreme conditions prevailing in SOFCs. Researchers from Hexis and Empa have joined forces to improve the operating life cycle time of SOFCs through the development of materials which are more resistant to the harsh chemical and thermal conditions in these cells. In addition, Hexis relies on Empa's expertise in system management to better integrate fuel cell technology into buildings and to evaluate its performance.

The cooperation between Hexis and Empa well illustrates the close link between institutes of applied research and companies in Switzerland. Companies with innovative ideas but limited capacity for in-house research and development can rely on public research institutions to overcome technological challenges and to find pragmatic solutions to their problems. Collaborations of this kind contribute strongly to the notion of Switzerland as an ideal location for research and operating base for companies with innovative products.

(bh,cs)

The award-winning fuel cell based combined heat and power unit Galileo 1000 N from Hexis, installed in the basement boiler room of an apartment building.



The Hexis SOFC consists of a circular shaped fuel electrode (anode), connected to an oxygen electrode (cathode) via a solid, gas-tight oxygen ion conductor (electrolyte) sandwiched between two metallic interconnectors. About 60 cells form a SOFC stack.

At temperatures between 800 and 900 degrees Celsius, two chemical reactions occur in different places. Fuel reacts on its way from the supply channel in the center of the stack to the outer rim of the anode. Preheated air is distributed via 4 channels to the cathode compartment, where oxygen is reduced on its way to the outer area.

Electrons released during the fuel reaction are utilized through an external circuit, providing electricity. The post-combustion of non-reacted fuel with air occurs in the afterburner zone, providing heat energy to supply a household with domestic hot water.

Natural gas from wood

Further Information
Further information about energy research at the PSI is available at:
www.psi.ch/media/energy-and-environment

Natural gas plays an eminent role in heating residential and commercial spaces and as a raw material in the chemical industry. To counter the climate change and safeguard the energy supply, great efforts have been made to substitute natural gas with so-called synthetic natural gas. Under participation of the PSI in Villigen, the European project Bio-SNG has made another important step towards that objective.

Wood has, within living memory, been the world's most important source of energy. However, for about the last two hundred years, it has increasingly been replaced by fossil fuels. Nowadays, wood experiences a renaissance as a widely available, renewable and carbon neutral source of energy. While wood can be directly used as biofuel for heating purposes, the technical infrastructure for energy supply in the industrialized countries is to a large extent attuned to natural gas. It is therefore reasonable to convert wood into a medium that better fits the existing natural gas-supply lines and heating units – and may be used even to power cars, too.

Turning wood into gas

There are various approaches to make synthetic natural gas from solid biofuels. Researchers and engineers have had to find new paths because the established chemical and physical processes for producing synthetic gas from coal could not be applied to wood.

Together with other European institutions and companies, the PSI has developed a conversion process that synthesizes synthetic natural gas from wood and can be used on a large scale for commercial purposes. In a first major step, wood chips are disintegrated and turned into gas using hot vapour. The gas is then purified. In a second major step, the gas is converted through a catalytic process into a mixture of methane and carbon dioxide. By separating carbon dioxide, the gas mixture is finally processed to natural gas quality and can be fed into natural gas-supply lines.

The conversion process, which was initially developed on the laboratory scale, has meanwhile reached industrial scale. Synthetic natural gas can be produced with an efficiency of more than 60 per cent, which moreover is expected to grow further by improving the two major steps. In addition to synthetic natural gas, waste heat is produced during the process, which can be reused to generate electricity or to feed industrial or district heating networks, increasing the total efficiency to more than 80 per cent.

Producing synthetic natural gas by means of this conversion process poses rather small technical and financial risks because the complexity of this technology is low compared to other technologies, and production on an industrial scale can be launched in relatively small processing units. In view of these advantages, high process efficiency, and compatibility with the existing gas grid, market opportunities are excellent.

Excellence in energy research

PSI researchers contributed especially to the second major step of the conversion process, benefiting from their extensive experience in national and international energy research and the development of hands-on processes for environmentally sound technologies.

Their contribution to the process of wood gas conversion is widely acknowledged. For example, PSI researchers were awarded the Watt d'Or 2009 prize of the Swiss Federal Office of Energy in the category of energy technologies.

(cs,aw)

ZAR – a foundation for sustainable waste management and urban mining

Switzerland's waste management sector has constantly improved its environmental performance since the mid-1980s. With the ban imposed by the Swiss Federal authorities in 1996 on the landfill disposal of combustible waste, the recycling rate for municipal solid waste from Switzerland has exceeded 40 per cent for many years and municipal waste incineration plants has become standard throughout the country.

Combustion of urban waste not only generates heat which can be used for district and long distance heating, but can also be deployed for electricity production. Furthermore, solid residues from this burning process contain valuable materials such as precious metals and rare earth minerals. For example, slag contains over ten per cent of ferrous metals and three to four per cent of non-ferrous metals. Waste slag can therefore be a true gold mine!

Waste as a key resource

In order to investigate the large-scale exploitation of solid combustion residues, Zurich's Cantonal Office for Waste, Water Energy and Air, the Association of Managers and Operators of Waste Treatment Plants and the Zweckverband Kehrichtverwertung Zürcher Oberland established a foundation for sustainable waste management (ZAR). Its mission is to sustainably manage resources and impose a closed raw material loop. The ZAR foundation aims to maximize the recycling of metallic and mineral parts from the waste slag, to reach the emission-free deposition of the remaining materials and to remove all dangerous substances in these materials. This would allow minimizing the amount of waste material needing to be deposited and, by eliminating toxic waste, obviate the long-term monitoring of permanent disposal sites.

The goals of the foundation

The goals of the ZAR foundation include using waste as a valuable resource for raw materials and exploiting the waste's energy and materials potential to its full extent. The foundation will ensure that all partners will benefit from the research projects and keep abreast of new developments at all times. The foundation interacts closely with the federal, regional and local governments, and with waste combustion sites, academic institutes and other organizations.

The benefits of the recovery of raw material from waste slag are obvious for a country with no natural resources such as Switzerland, where about three million tons of combustible waste accumulate every year. After combustion, one forth remains in the form of slag, filter ash and sludge from the flue gas scrubbing process. Today, these remnants are deposited in landfill sites. However, a significant portion of ferrous material (52,000 tons per year) could be recovered without contaminations and recycled into steel production. Similarly, 19,500 tons aluminium could be recovered per year, thereby saving large amounts of energy and carbon dioxide emissions for production. Other metals such as copper and alloys that need large amounts of energy for production in addition to jeopardizing the environment can also be optimally recovered. Thus, sustainable waste management is also sustainable raw material management and depends largely on a closed raw material loop.

(hm)

Neuchâtel – energy consumption in urban district reduced by 20 per cent

Further Information
More detailed information about the HOLISTIC project and the city of Neuchâtel are available at:
www.holistic-ne.ch

The European HOLISTIC project aims to improve the energy efficiency in European communities and to show how changes in all aspects of community life – ranging from housing and industries to leisure facilities – can contribute to a transformation towards sustainability. The Swiss city of Neuchâtel is involved in the HOLISTIC project together with Dundalk (Ireland) and Mödling (Austria).

All communities share the common objective of substantially increasing the supply of renewable energy for the purpose of significantly improving the energy performance of the built-up environment and establishing intelligent supply management.

For Neuchâtel, the specific target is to save more than 20 GWh/year of non-renewable energy in a typical urban district, the Mail/Maladière/Station area. This area includes different building types such as the municipal swimming pool, university buildings, businesses, shops and residential buildings. The area accounts for 17 per cent of the whole city surface and is home to 4700 residents. To reach this ambitious energy-saving target, three types of activities are being implemented:

Retrofitting old buildings and constructing energy efficient structures

Firstly, important buildings are retrofitted: the building shell is insulated, windows are replaced, and controlled airflow is established. Reduction of energy consumption in these renovated buildings may in the end vary between 34 to 65 per cent of the initial amount. A particularity of Neuchâtel in this project is the respect with which historical buildings such as the main buildings of the University are renovated (figure 1).

When large new buildings are designed, particular attention is paid to the principles of bioclimatic architecture and energy efficiency (figure 2). These buildings need 30 to 40 per cent less energy than buildings that meet the current Swiss building standards. Moreover, the appropriate choice of building materials significantly reduces embodied energy consumption, and energy supply is mainly based on renewable energy resources.

Increasing the proportion of renewable energy

Secondly, in addition to measures taken for the specific purpose of improving particular buildings, the production of renewable energy is significantly increased in the district, e.g. by covering the new stadium with photovoltaic panels. When the HOLISTIC project is terminated in the year 2012, about 4000 square metres of photovoltaic panels will produce 340 MWh/year of renewable electricity. Furthermore, hydroelectricity will be generated at the outlet of the sewage plant and on the city's two rivers. Finally, wood will partly replace natural gas for the district's heating requirements, amounting to 8000 MWh/year.

Optimizing energy management for building and district heating networks

Thirdly, significant improvements were realized in the district heating system by lowering the water circulating temperature and replacing the connected buildings' heat exchangers with more efficient systems. These measures allowed savings of over 1000 MWh/year. Additional measures are proposed in several important buildings in order to enhance the management of the heating and lightning systems, which should permit to save another 10 per cent of the energy required.

Together, the individual measures amount to significant energy savings. Neuchâtel is demonstrating that the ambitious goals specified in the HOLISTIC project can be achieved. The measures taken by the city will be an incentive for other cities in Europe and world-wide – to follow in its footsteps.

(fad,acc)

Figure 1: The main University building was energy retrofitted with special attention to its high architectural value.

Figure 2: These new buildings, which are easily accessible by public transport, host apartments and professional schools. They were designed to reduce energy consumption.

Doing business with the Sun

Further Information
For more information about CTI and its services please see:
www.kti.admin.ch

With its flexible photovoltaic modules, Flisom AG aims to revolutionize the solar power market. Although this company's technology is state-of-the-art, raising capital was a challenge.

Founded in 2005 as a spin-off of the ETH Zurich, Flisom specializes in so-called flexible thin-film CIGS solar cells. Thanks to the high degree of light absorption, these solar cells are only two to five micrometres thick – around 30 times thinner than a human hair. A so-called roll-to-roll process is used to apply thin semi-conductor layers onto a special polymer substrate. Accordingly, Flisom's solar cells require little material, may be produced in a cost-effective way, and are easily transportable.

A functional prototype is currently being built, and a commercial solar panel unit will be set up starting in 2013. Use of Flisom's flexible solar cells on buildings seems to offer the greatest market potential because the solar panels can be manufactured to different sizes and easily installed on facades or roofs. Other possible applications include vehicles, laptops and hand-held devices.

The promising technology and bright market prospects have earned Flisom many distinctions: the CTI Start-up label (see below), Red Herring 100 Award for the most promising technology firms in Europe, and the WEF Technology Pioneer in the area of energy – just to name a few.

Thanks to the Innovation Promotion Agency CTI and a private investor, Flisom AG is finally able to bring its technology even closer to the market. The Indian Tata Group realized the potential of Flisom's technology and came forward to invest in the company despite the global crisis year of 2009. Their interest in the company is proof that the start-up is a technological leader when it comes to flexible CIGS solar cells.

(ns,cs)

The Commission for Technology and Innovation CTI
CTI is Switzerland's major instrument for the promotion of knowledge and technology transfer between public research institutions and businesses. CTI aims to leverage innovation by accelerating the process of turning research know-how into innovative products, processes, and services.

CTI stimulates innovation in two principal ways. CTI's main field of activity is the promotion of collaborative R&D projects. When a company teams up with public research institutions for a joint R&D project, they can submit a funding proposal to CTI. Funding covers the universities' research staff costs up to about 50 per cent of the total project costs.

Strengthening entrepreneurship in Switzerland is another important field of activity for CTI. It promotes innovative entrepreneurship via two specific programs: the "venturelab" education and training program, aiming to motivate students to become entrepreneurs, and the coaching program "CTI Start-up".

After passing the CTI Start-up program successfully, start-up companies may be awarded the highly acclaimed CTI Start-up Label, a recognized certificate for quality and a door opener to venture capital and business angel funding.

In recent years, clean technologies have become more and more important both in collaborative R&D projects and in CTI Start-up coaching programs. Moreover, CTI launched the "Innovation-Cheque Cleantech", a funding program designed to help SMEs in Switzerland to start research and innovation activities in the cleantech field.

Cleantech Switzerland - your link to Swiss cleantech competence

Further Information
You can find further information on Cleantech Switzerland at:
www.cleantech-switzerland.com

Cleantech Switzerland supports small and medium Swiss enterprises in tapping into cleantech markets around the world with information and contacts. Foreign investors and companies are offered a comprehensive overview of the Swiss cleantech sector as well as direct contact to the relevant firms.

Cleantech Switzerland is the export platform for the Swiss cleantech sector. It was developed by Osec, the Swiss foreign trade promotion network, on behalf of the Federal Government and has been in operation since July 2010. At the center of its activities is the establishment of business relations between cleantech companies in Switzerland and potential customers in target markets. For this purpose, Cleantech Switzerland maintains a company database on its web portal, in which cleantech companies can register themselves in order to showcase themselves to export markets.

Potential foreign customers can use the database to gain an overview of the Swiss cleantech landscape and selectively search for sustainable products and services. Experts in the target markets, so-called business scouts, establish contact between customers and project partners by identifying potentially interesting projects for Swiss companies. These projects are then assessed and put forward to the relevant Swiss companies by senior industry advisors based in Switzerland. In this way, foreign demand is directly linked with Swiss supply.

Cleantech Switzerland is legally structured as an “association of associations”, whose members are established business combinations or groupings such as Swissmem (Association of the Swiss engineering, electrical and metal industry) and SVUT (Swiss Association for Environmental Technology). Cleantech Switzerland supplements the services of these associations with export support. North America, China, India as well as selected EU countries (Great Britain and Poland) were designated as main target markets. Other individual markets with particular characteristics such as Hungary, Turkey, the Arabian Gulf and Mexico are also being selectively targeted.

Innovative Swiss cleantech companies

Cleantech Switzerland presents the company profiles of numerous innovative Swiss cleantech companies in its company database. One such company is Ganser CRS, which provides environmentally-friendly diesel engines in the field of common rail injection systems (CRS). This technology is used for equipping ships, locomotives, and construction machines with electricity generating engines. Diesel engines equipped with CRS by Ganser CRS (Osec Export Award finalist 2010) are more powerful, reduce diesel consumption and make an active contribution to reducing greenhouse gases.
The company I.C.E. AG, as a further example, offers intelligent solutions for incinerating rubbish, waste, biomass and sewage sludge. This service provider, whose strength lies in thermal waste disposal and plant construction, supports waste incineration operators in optimising, maintaining, retrofitting, expanding and rebuilding plants.
The topic of water is of central importance with regard to the sustainable use of natural resources. Adamant Technologies SA offers advanced technology in the field of wastewater treatment, water sensing and metrology with its method of diamond coating. Micro-organisms found in drinking water, such as bacteria or viruses, are destroyed and organic pollutants are separated from industrial wastewater. Adamant Technologies’ achievements have already won many awards. In 2004, it won the Bronze European Environmental Press Award.

(br)

Cleantech in western Switzerland: Dynamism and competence

Further Information
More detailed information about CleantechAlps and cleantech in western Switzerland is available at:
www.cleantech-alps.com

Cleantech is a vibrant sector in western Switzerland. Projects such as Solar Impulse often hit the front page, but the sector is not only limited to these much publicized projects. Whether within companies or at the level of research and training, all the necessary competence for facing the challenges of green technologies is available on the doorstep. Local stakeholders and foreign companies wishing to develop further can rely on the assistance of the CleantechAlps cluster.

Clean technologies have important flagships in western Switzerland. These are projects such as Bertrand Piccard's solar aeroplane, Solar Impulse, the solar catamaran PlanetSolar, which is operated out of Yverdon-les-Bains, and the solar and wind-powered car Icare, supported in particular by the Vaud and Fribourg Schools of Engineering.

These three projects, which have toured the world, contribute to enhancing the visibility of regional clean projects. In addition, there are numerous other academic projects, especially with regard to smart grids, such as SmartEnergy, which is spearheaded by the University of Applied Sciences Western Switzerland. This project, which has great potential, proposes a high-performance solution for the management of energy in order to ensure the balance between production, consumption and storage. It is a great example of the competence of the regional cleantech stakeholders – both academic and industrial.

In addition, cleantech in western Switzerland is supported by an offering of very substantial study programs. No less than 120 training courses at various levels and of differing duration exist regionally, according to a recent internal study commissioned by CleantechAlps. Research is also investing a lot of time in the cleantech sector — no fewer than 65 research bodies are participating in this field, which accounts for more than a third of all research institutions in the region.

Seven priority sectors

Regional stakeholders and foreign companies wishing to develop further at local level can rely on CleantechAlps. This inter-cantonal platform is supported by the State Secretariat for Economic Affairs. It is very well established in national and international networks and ensures the coordination of the national Cleantech Switzerland platform in western Switzerland. CleantechAlps facilitates business development in the seven priority domains: photovoltaic energy, small-scale hydraulic energy, waste recovery, water, smart grids, industrial ecology and energetic efficiency of buildings.

Each of these domains is sponsored by an association of stakeholders. For photovoltaic energy, for example, the region can depend on prominent companies such as DuPont, Applied Materials, Flexcell and also 3S/Meyer Burger. Waste recovery is supported by pioneers in this area such as Geneva's Serbeco or Quantis and its international holding, which is active in Europe and North America and a leader in life cycle analysis and sustainable development.

Cleantech gateway in western Switzerland

These top-level stakeholders show that western Switzerland has a network of solid and competent actors in the field of Cleantech. The economic and technological fabric is therefore ideal for growth. As a regional gateway for cleantechs, the cluster CleantechAlps is available to help facilitate the interaction and integration of partners from varying sectors.

(ep)

Return on sustainable investment

Further Information
For further information about Forma Futura Invest AG please see:
www.formafutura.ch

Over the last years, plenty of financial products promoted as sustainable have appeared on the market. For both professional investors and individuals it is a challenging task to distinguish between respectable products and greenwash. Antoinette Hunziker-Ebneter, CEO of Forma Futura Invest AG, explains how to keep track of sustainable investment.

The concept of sustainability has become increasingly popular both in the industry and the financial services sector. Outsiders often find it very difficult to identify and distinguish between the different notions of sustainability. Ms Hunziker-Ebneter, how would you define the term sustainability and what are sustainable investments?
We understand the concept of sustainability to mean sustainable quality of life: In fact, we use the term as it was defined in the UN-initiated Millennium Ecosystem Assessment, which has been investigating the effects of changes in the ecosystem on human well-being. According to this report, quality of life consists of several elements, i.e. good health, a sufficient supply of goods for basic needs, physical security, and satisfactory social relationships. Add to this freedom of choice and action, which requires an adequate level of education. The Millennium Ecosystem Assessment calls for creating and enhancing the quality of life and preserving it for later generations while maintaining the capacity of the earth's ecosystem.

Our company's approach is to focus on investing only in firms that promote sustained quality of life while offering risk-adjusted returns.

What are the practical aspects of this approach?
We choose our investments systematically, using almost 200 different indicators based on which we evaluate a company's sustainability and financial potential. Among these are, for example, the following questions: how do corporate executives manage their company and personnel; how do they support innovations; how much of the company's profit goes into bottom-line earnings and into research and development, respectively; how are scarce resources allocated, and does the company offer products and services that help improve human well-being in marginal regions or developing countries? Another factor to be assessed is a company's dynamic progress towards sustainability. As a consequence, companies may be accepted for inclusion in our portfolio even if they cannot be regarded as sustainable according to the above criteria, as long as they show clear signs of moving in that direction. This can be a significant incentive for companies to strive for sustainability, since their development is supported by the financial commitment of our clients.

A focus on sustainability exerts an immediate impact on staff motivation and the company's attractiveness for qualified workers from all over the world. In this way, focusing on sustainability contributes directly to the development potential and the competitive position of these companies. That is why sustainability is not a stab in the back of companies as was often held in the past, but the very opposite.

Meanwhile, there are a considerable number of companies of interest to us, where the concept of sustainability is well anchored and integrated in their corporate governance. Companies from Scandinavia have progressed especially far in this context. However, there are good examples in Switzerland as well, for example, ABB, Geberit and Holcim.

How do you collect the data necessary for assessing a company's sustainability?
We rely on collaboration with an external research network for a pre-selection. Upon completion of this pre-selection, we evaluate the companies that might be of interest to our clients. On the one hand, an analysis of the financial situation is performed to ensure that companies have a potential for sustainable growth. Then again, a sustainability analysis in line with what was said before is carried out. This allows us to determine whether the term of sustainability is used by the company as a convenient alibi or is actually part of the corporate culture. Only those companies that have passed these three steps will be included in our portfolio.

Naturally, the proportion of time and cost for such multi-tiered analyses is much higher than for mere financial analyses, but it makes a lot of sense to me since companies are viewed from a holistic and integrated perspective.

How large is the market for sustainable investments in Switzerland?
Up-to-date figures can be retrieved from the European Sustainable Investment Forum. Surveys show that market growth for sustainable investments in Switzerland has tripled in the past five years to reach a volume of more than 20 billion euros.[1] Growth is clearly much more pronounced than in the overall financial market.

The majority of experts surveyed see large increases in sustainable investments over the next ten years, going so far as to predict that the investment volume may even double during this period. Personally, I do not doubt that the market for sustainable investments will gain increasing influence in the financial sector and will change it in the medium run.

The market for sustainable investments partly lacks transparency. What would you recommend to someone who is interested in sustainable investments and wishes to get some insights?
A seal of approval for sustainable investments is unfortunately not yet in place. Potential investors should therefore develop their own expertise and try to find out how sustainability is understood by the financial products providers, how many persons work there in a sustainable environment, and what proportion of sustainable financial products the providers include in their portfolios. While this means investing a certain amount of time, it is well worth the effort. In the final analysis, investing money is a matter of trust: clients want to build a durable relationship with a provider and use their financial resources, provided that they are adequately invested, to play an active role in their countries' economic and social development.

(cs,hm)

[1] I. Knoepfel, B. Janezic, Sustainable investments in Switzerland 2009, 2010

Antoinette Hunziker-Ebneter
Antoinette Hunziker-Ebneter is founding partner and Chief Economic Officer of Zurich-based Forma Futura Invest AG, an independent asset management company for sustainable investments. Prior to her present engagement, she was member of the Group Executive Board of Julius Bär and Head of the Swiss Stock Exchange.

Facts and figures

The Swiss cleantech sector faces bright prospects

There is widespread agreement that cleantech is an increasingly important sector that is strongly developing both technologically and economically. Switzerland has recognized its commercial potential early on. The country has been (and still is) pioneering environmentally sound technologies, as evidenced by the early increase in cleantech-related patent applications from Swiss applicants. Switzerland ranks among the leaders in terms of innovation activity and continues to consolidate its position, as evidenced by the high number of patent applications per capita (figure 1). Figure 2 shows the industry sector distribution of Swiss patent applications for the mitigation against or adaptation to climate change.

Energy efficient technologies play an important role in Swiss companies

The KOF Swiss Economic Institute has investigated the economic mechanisms behind the generation and diffusion of energy efficient technologies in Switzerland (see p.24). The probability of adopting energy efficient technologies is significantly affected by characteristics such as corporate size, R&D activities, and environmental awareness.

Figure 3 shows the share of investments in Swiss companies dedicated to energy efficient technologies, reflecting the economic importance of applying these technologies. Most industries dedicate between 5 and 7 per cent of their total investments to energy efficient technologies. The large values for the paper industry and electrical machinery (more than 12 per cent) and for electricity providers (48 per cent) stand out in a particularly pronounced fashion.

Independently of corporate size, the most important motivation for companies to adapt energy efficient technologies is “high or increasing energy prices” and “environmental concerns” (figure 4). For medium-sized enterprises, the “existing or expected demand for environmentally friendly products” is also relatively important, while the “expected taxation of energy” plays a significant role for adopting energy efficient technologies for large or small companies.

More than 25 per cent of inventors in energy technology have developed new products in the field of “heat recuperation systems” (figure 5). “Solar heat and “photovoltaics” are other fields with a relatively large share of innovative companies, whereas “superconductors” and “carbon capturing and storage (CCS)” are found at the lower end of the scale.

Facts and figures (continued)

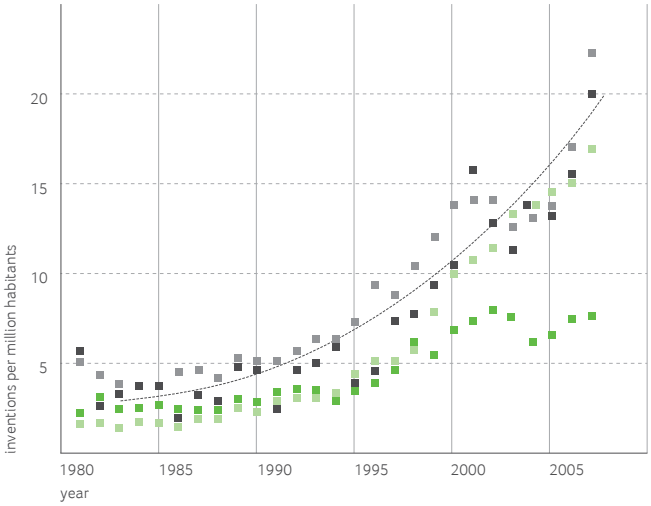


Figure 1
Number of inventions related to the mitigation against or adaptation to climate change which were filed for patent protection, per capita

- CH
- DE
- USA
- JP

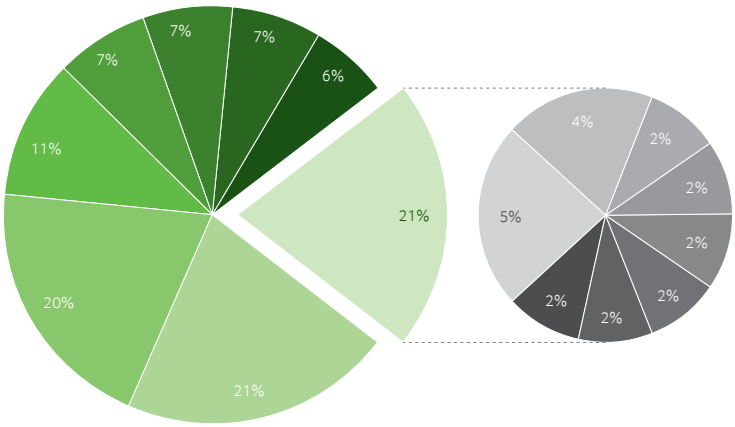


Figure 2
Technologies for mitigation or adaptation against climate change: Sector distribution of Swiss patent applications (in per cent)

- Energy machinery
- Accumulators, battery
- Fabricated metal products
- Basic chemical
- Other electrical equipment
- Non-specific purpose machinery
- Electronic components
- Signal transmission, telecommunications
- Other transport equipment
- Rubber and plastics products
- Non-metallic mineral products
- Special purpose machinery
- Petroleum products, nuclear fuel
- Basic metals
- Electric motors, generators, transformers

The estimation is based on patent documents which were identified by the European Patent Office as related to the mitigation against or adaptation to climate change. The patent documents were assigned to individual inventions by means of World Patent Index data.

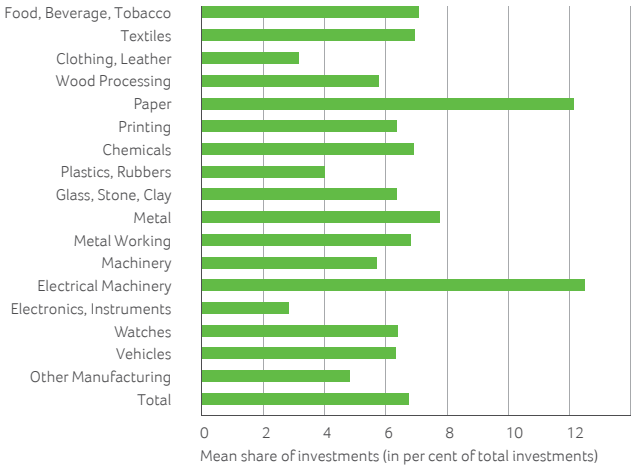


Figure 3
Mean share of companies' total investments dedicated to energy efficient technologies (in per cent). Owing to the exceptionally high value (48 per cent), the electricity provider sector is not plotted.

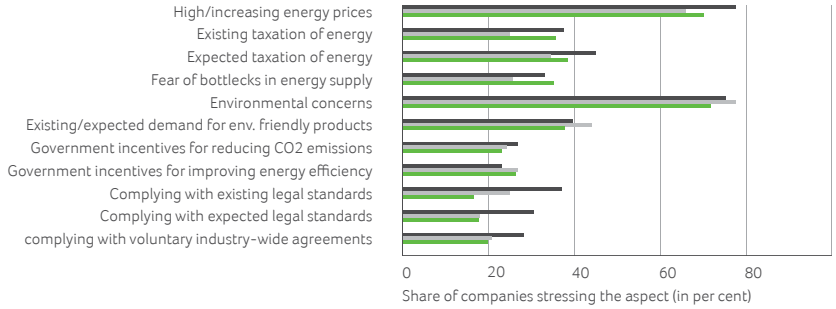


Figure 4
Motives for the introduction of energy efficient technologies: Share of companies giving the individual aspects high priority (in per cent).

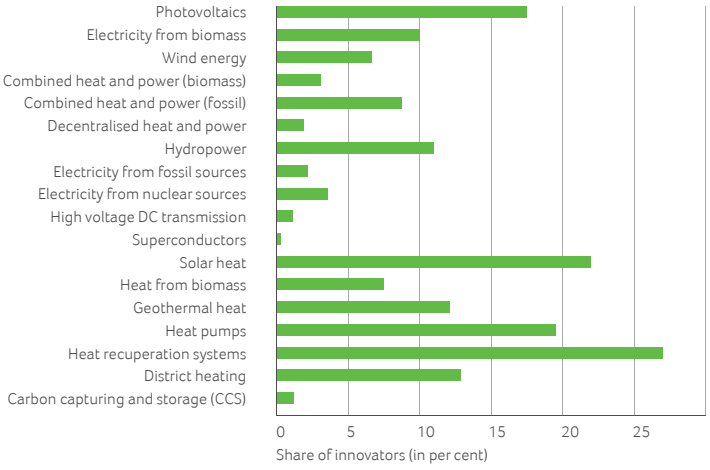


Figure 5
Share of innovators in energy production and transmission technologies, by technology (in per cent of all innovators in energy technologies).

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs FDEA
Federal Office for Professional Education and Technology OPET

Eidgenössisches Institut für Geistiges Eigentum
Institut Fédéral de la Propriété Intellectuelle
Istituto Federale della Proprietà Intellettuale
Swiss Federal Institute of Intellectual Property

SWISS CLEANTECH

csem

EMPA
Materials Science & Technology

osec
Business Network Switzerland

SIX SWISS EXCHANGE

Cleantech ALPS
Western Switzerland Cleantech Cluster

PAUL SCHERRER INSTITUT
PSI

Impressum

Steering committee
Florence Amez-Droz (CSEM)
Andrea von Bartenwerffer (SIX Swiss Exchange)
Nick Beglinger (swisscleantech)
Philipp Dietrich (Paul Scherrer Institute PSI)
Manfred Grunt (Federal Office for Professional Education and Technology)
Michael Hagmann (Empa)
Hans Jörg Jegge (Osec)
Heinz Müller (Swiss Federal Institute of Intellectual Property)
Eric Plan (CleantechAlps)
Christian Soltmann (Swiss Federal Institute of Intellectual Property)

Project management
Christian Soltmann

Editorial staff
Christian Soltmann (cs), Heinz Müller (hm),
Florence Amez-Droz (fad), Eric Plan (ep),
Anne-Claude Cosandey (acc)

Editorial assistance
Melanie Bucher (Swiss Federal Institute of Intellectual Property)
Corinna Müller-Strehler (Dixit Übersetzungen GmbH)

Concept, layout and design
Frey Communications SA
TGG Hafen Senn Stieger

Print
Swissprinters AG

FSC www.fsc.org
MIX
Papier aus verantwortungsvollen Quellen
FSC® C009086

Illustrations courtesy of
ETH-Studio Monte Rosa/Tonatiuh Ambrosetti (front page)
Hexis AG (page 35)
Bauart/Y. André (page 39)

Supported by

S•E•C•A
Swiss Private Equity & Corporate Finance Association