energy extra 3.04

Information
Swiss Federal Office of Energy
and SwissEnergy

June 2004

Pioneering spirit

If renewable energy has failed to excite more than marginal interest, it is because the concept is still linked in the public's mind with a prohibitive price and limitations in both comfort and mobility. This is the bias that has to be overcome because nobody is willing to give up living standards, even if the planet ends up paying the price. Our grandchildren will no doubt make their adjustments to living a life without oil but, for the present, we have to deal with the fact that human beings are generally more motivated by their own interests in the short term than the long-term interests of their species or the environment.

But since human nature doesn't change much, we can try to take advantage of its habits. We can try to generate consumer-taste appeal for sustainable development in general and renewable energy in particular. We can show that a big new market loaded with opportunity is at the door for investors acute enough to hear it knocking. We can invoke the scientific dynamic, cultivate pioneering spirit, acclaim a new mind-set – one that will earn users of renewable energy an admiring tip of society's hat. It cannot be a case of twisting the public's arm to get on the road mapped out by Rio, Kyoto or Bonn, but rather of saluting those who invent or use new technologies sensitive to the environment. Before long, it could become socially old fashioned and also flatly unpopular to guzzle fuel, unnecessarily heat and cool public or private interiors and buy materials that can't be recycled.

Bertrand Piccard

The 46-year-old psychiatrist and aviator made the first non-stop balloon flight around the world. Now he's planning to do the same in a solar plane – in several stages.
"Like Solar Impulse's pilot, we only have a limited supply of energy at our disposal. If we realise this too late, we will crash before the end of our journey."

Until now, renewable energy, often ideologically the preserve of small minority political groupings, hasn't had the lift of skilled marketing and promotion in winning public acceptance. It is with that in mind that I have launched, with the Solar Impulse team and in partnership with the EPFL (Federal Institute of Technology in Lausanne), a project to circle the world in a sun-powered aircraft.

People find bold adventure fascinating. They respond to the same dream that drives pioneers and explorers. Solar Impulse seeks to mobilize exactly that — the spirit of adventure dormant in all human nature. Once awakened, we will seek to enlist its support of technologies that enable sustainable development and its commitment to renewable energy. Our plane is a symbol. I don't mean that anyone in the future is likely to be piloting 300 people in a solar aeroplane, I mean that this is a symbol of good sense that should be common to us all. After all, are we not each of us, like Solar Impulse's pilot, subject to energy limits? Otherwise, we too will crash before the end of the journey.

I invite those of you who welcome these sentiments to visit *www.solar-impulse.com.*

Dr Bertrand Piccard

swiss energy

EDITORIAL

Dear reader

From 1 to 4 June, 2004, Germany will host the International Conference on Renewable Energy 2004, as announced by Chancellor Gerhard Schröder at the World Summit on Sustainable Development in September 2002 in Johannesburg. The conference – renewables 2004 – will chart the way towards an expansion of renewable energies worldwide, responding to the call of the Johannesburg summit for the global development of renewable energy.

Historically, Switzerland's longest-serving and most important source of renewable energy has been hydropower. Other renewables including solar, wood, biomass, wind, geothermal and ambient heat, also play an increasingly important role in Switzerland. There are considerable research efforts directed towards the further development of these technologies.

This special issue of the energy extra *magazine, a bi-monthly publication for the general public issued by the Swiss Federal Office of Energy, will provide you with an overview of Swiss renewable energy policy and will illustrate some of our country's recent developments and practical approaches in this field.*

Marianne Zünd
Head of Communication
Swiss Federal Office of Energy,
Berne

Contents:

SURVEY

Renewable energy in Switzerland

Plenty of hydropower, practically no fuel resources, resourceful minds – from its special situation, Switzerland has adopted an energy programme with a considerable proportion of renewable energy sources.

Switzerland decided very early to exploit its hydropower potential. Otherwise lacking fuel resources, it now ranks among the countries with the highest share of hydropower as a primary source of energy, although the potential is regarded as practically fully exploited.

So-called "new" renewable energy sources have registered some success since the beginning of the 1990s, but their potential is a long way from being fully exploited.

Waste combustion and biomass contribute the largest share to the use of the renewables. Switzerland is one of the world leaders in the deployment of heat pumps and photovoltaic capacity. Altogether, renewable energy sources (including hydropower) account for 21 percent of Switzerland's primary energy and around 60 percent of total production of electricity.

Switzerland exports 10 to 15 percent of its electricity generation as "clean energy" to neighbouring countries. Electricity companies increasingly offer certified "green" electricity, for which around 5 percent of consumers are prepared to pay more.

The solar energy plant on Mont Soleil.

Politics. A safe, efficient and environment-friendly energy supply as well as economic and rational energy consumption are constitutionally mandated in Switzerland (and reinforced by the Energy Law of 1998).

Acting in accordance with this constitutional mandate, the Swiss Federal Council launched the 10-year programme *Energy2000* in 1990. The target for electricity production from renewable energy sources was more than fulfilled by the end of this period, although the targets for heat generation were not quite reached.

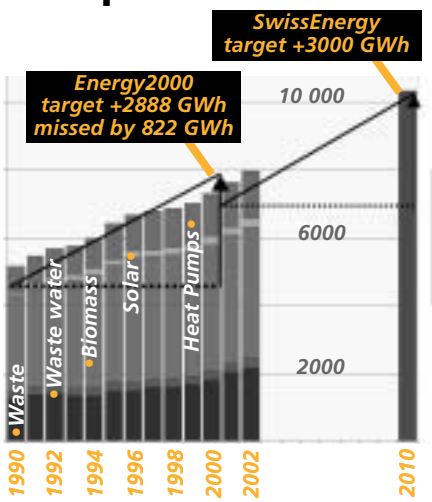
The lessons from *Energy2000* were incorporated in its successor, the *SwissEnergy* programme, whose targets should be reached by 2010.

The targets set by *SwissEnergy* as part of the Swiss contribution to the Bonn plan of action, are:

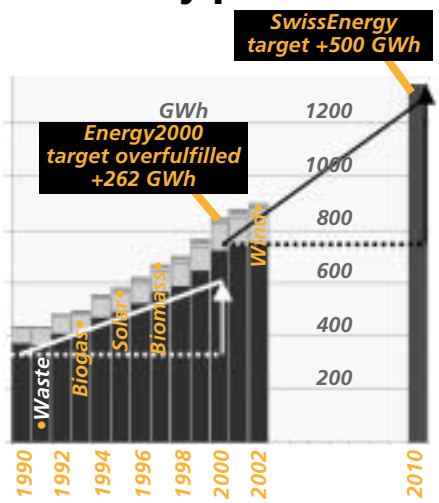
- An increase of the share of electricity production from "new" renewable energy sources of 1 percentage point by 2010, i.e. from 1.3 to 2.3 percent (or 500 GWh).
- An increase in the share of heat generation from "new" renewable energy sources of 3 percentage points (or 3000 GWh) by 2010.

In the 1990s, around CHF 287 million (€ 185 million) was allocated to the furtherance of the new renewable energy sources. The federal government subsidised the use of fuel wood with an additional CHF 45 million (€ 29 million) after the storm "Lothar" had devastated large areas of forest in late 1999.

Heat production



Electricity production



Waste combustion and biomass contribute the largest share of electricity production from new renewables.

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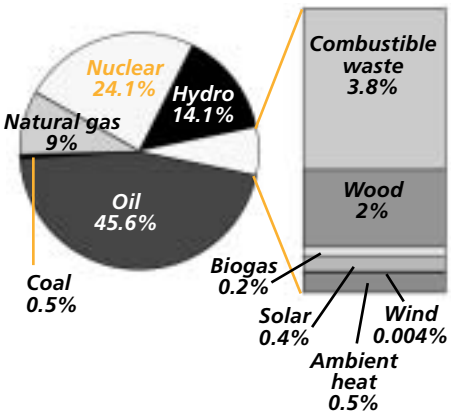
The *SwissEnergy* programme allows for the yearly federal allocation of CHF 28 million (€ 18 million) to renewables (plus additional co-financing from cantons and local authorities). *SwissEnergy* wants to motivate the cantons to greater harmonisation of their regulation. As regards heat generation the programme has stayed on course up till now, but the efforts in electricity production have to be doubled.

Primary energy



Including hydropower, the renewables contributed 21% of Swiss energy supply in 2002.

Guiding principles. New renewable energy sources can mostly only penetrate the market with massive state aid. In Switzerland, politics has a significant say in the utilisation of renewable energy sources.

With the direct democracy system, Swiss voters can continually influence legislation by means of popular votes – not always to the benefit of renewable energies. In 2000, three proposals for taxing non-renewable energy sources were rejected. In 2002, an electricity market law (with articles for the promotion of renewable energy) was turned down, as were proposals to phase out nuclear energy in 2003.

Another guiding principle of Swiss energy policy comes from federalism and the *subsidiarity principle* that goes with it: the Federal state *steers* with framework directives and *delegates* the implementation to the cantons.

This is the case for instance with *feed-in tariffs*. At the beginning of the 1990s, Switzerland was one of the first European countries to introduce feed-in tariffs.

Voluntary agreements. Furthermore, voluntary agreements with economic players are another favoured energy policy tool. They were first introduced in 1990. One lesson from the programme of the 1990s was that voluntary measures are not stringent enough to reach ambitious targets. That is why the 2000 CO_2 Law, which stipulates a 10% reduction in CO_2 emissions by 2010 in accordance with the Swiss Kyoto target, calls for introducing a CO_2 levy from 2004 at the earliest if it can be seen that the target will not be attained through voluntary measures. Companies that sufficiently reduce their CO_2 emissions will not be subject to the levy.

Research. The Swiss are well advanced in the area of research, development and demonstration (RD&D). Between 1990 and 2001, Switzerland was one of the six industrialised nations that contributed 82 percent of RD&D in the renewables sector. In 2001, some 30 percent of Swiss energy research funds were allocated to renewable energy projects.

The examples on the following pages bear witness to Swiss creativity in the area of renewable energy sources.

INTERVIEW

"We have been overtaken"

Five questions to National Councillor Doris Stump, member of the Swiss delegation to the Bonn Conference.

What does the Swiss delegation expect from its participation at the Bonn conference on renewable energy?
We are interested in developments in other countries. We can learn from positive examples and experiences, communicate our success stories and make our products known.

In which areas can you highlight Switzerland as a pioneering country, or a country which can advise and/or support other countries?
The promotion of the Kompogas project has been extremely successful. Biogas is also being used to power vehicles. Kompogas plants are under construction in other countries. Furthermore, the Swiss quality assurance concept for heat pumps and large wood-heating systems, for example, is a subject of great interest in various countries and in some cases has been taken over entirely. Switzerland has also performed pioneering work in the area of integrating photovoltaic installations. This includes aesthetic integration in pitched roofs, the use of translucent modules in roofs and the use of solar cells in noise abatement walls. The overall concept is that of the multi-functionality of solar systems.

In what areas can Switzerland benefit from international cooperation?
International cooperation is of major significance for all areas of energy efficiency and renewables. Cooperation has a long history in research. In terms of P&D and bringing to market, cooperation must be fundamentally strengthened, especially in view of the fact that these final development stages are cost-intensive and the small Swiss market alone cannot repay the development costs.

We are also able to present our modern technologies to an interested international audience. At the same time we can study the foreign support programmes for renewables and learn from their experience.

Dr Doris Stump, 54, now a publisher, originally a high-school teacher of German and English, is the vice-president of the Swiss Agency for Renewable Energy and Energy Efficiency. Since 1990 she has been a municipal councillor in Wettingen, and since 1995 she has sat as a social democrat in the National Council, the lower house of the Swiss parliament.

What role does the AEE (Swiss Agency for Renewable Energy and Energy Efficiency) play in the international dialogue on renewables?
So far the individual member associations of the AEE have fostered contacts with European countries. The AEE itself has concentrated on activities in Switzerland. I shall be availing myself of the opportunity to make contact with representatives of other energy agencies in order to network ourselves internationally.

How has Switzerland's position on renewable energy changed over the last few years compared with other countries?
The high proportion of hydropower in the Swiss electricity supply system gave us a leading position with regard to renewable energy. For a long time our country was therefore a model as far as promoting new sources of renewable energy within the framework of *Energy2000*. In the meantime, other nations have overtaken us. The EU programme to double the share of renewable energy by 2010 is worthy of particular mention in this context. In various member states of the Union, large-scale wind power installations, solar power plants and biogas plants are being built and tens of thousands of new jobs have already been created. There is consequently a pressing need for an effective support programme in Switzerland.

KOMPOGAS

I've got a tomato in my tank

Some people put a tiger in their tank. Walter Schmid, 58, a former racing driver and entrepreneur in Glattbrugg puts a tomato in his: he fuels his car with biogas produced from organic waste.

In March 2003 in Austria, when Michael Gorbachev presented him with the silver *Global Energy Award*, he was clear about one thing: "This is the best prize going in the environmental sector!" Walter Schmid, 58, founder and president of Glattbrugg's Kompogas AG, had been nominated for the "renewable energy Oscars", a veritable elevation to the energy hall of fame! 1300 projects from 98 countries were nominated in the worldwide competition.

The beginnings. The building contractor did not envisage such dizzy heights at an early age, though he always wanted to do more than just build things. So in the eighties, Schmid took up renewable energy, built solar collectors and ground heat collectors, electric cars and low-energy houses, installed wood, single-gas and atmospheric heat pump heating systems, geothermal and photovoltaic systems.

Then he came to biogas. "I was always fascinated by the idea that you could travel a kilometre on a kilo of rotten tomatoes," laughs Schmid, who was European autocross champion six years ago ("my dream: that Schumacher will also drive on biogas!"). He studied scientific literature and built a small test installation on his balcony, powered by chicken droppings, sewage sludge and kitchen waste. "One day it all exploded. What a mess! But I just knew there was something in it!"

In 1989 he founded Kompogas AG Glattbrugg. Today it has some 45 employees. The Confederation and the canton of Zurich supported the development of the first system, which went into operation in 1992 in Rümlang. "We were the first to process biogas into a vehicle fuel," he recalls. Today his company's gas-powered cars travel around with an advertisement on them: "Your kitchen waste is my fuel".

The system. Kompogas gets its bio-waste from green waste disposal – mainly from municipalities and wholesale distributors. In the reception bunker, foreign matter is removed, shredded and fed into the fermentation reactor, where within two weeks micro-organisms decompose the bio-waste at 55 to 60°C, in the absence of oxygen, to produce biogas and compost.

Some of the biogas drives a combined heat and power plant which generates power via a generator, and heat. The remainder is fed into the natural gas network or to the Kompogas filling stations. The sterile (weed-free) compost returns to the ecological cycle as fresh compost and liquid fertiliser.

"I pinched the idea from the horse: it eats grass in front and leaves behind manure, from which grass grows again"; this is how Schmid summarises his process. The key innovation is that he obtains energy from organic waste instead of destroying it: "Composting alone consumes energy; and incineration or tipping have environmental impacts". The Kompogas process is CO_2-neutral: a biogas car emits only as much CO_2 as the plants have extracted from the air.

From each garbage truck, Schmid obtains the equivalent of 600 litres of petrol, and the price of his tax-exempt fuel is about 30% lower. If all of Switzerland's organic waste was fermented in biogas systems, some nine percent of car traffic could be replaced by gas-powered vehicles.

Already about 750 cars and trucks are filling up at gas filling stations. When cars travel beyond this network, they can switch to petrol. Citroën, Fiat, Ford, Opel and Volvo currently offer climate-friendly hybrid vehicles.

Success. Schmid's main concern is for the raw material: compostable waste collection is not yet common everywhere: "There is massive energy potential: more than a third of all household waste is organic material!" Kompogas currently records a 20% increase in material. Kompogas marketing manager Daniel Würgler: "Many branches of industry, such as large bakeries or breweries, are looking for more environmental methods".

At present, 21 plants are in operation – 7 in Switzerland, 11 in Germany, 1 in Austria and 2 in Kyoto (Japan), a potent symbol. Six more are planned: 4 in Switzerland, and one each in Passau, Rioja and on the island of Martinique. Licensees cushion Schmid's risk. Würgler says: "Our company is the proof: protecting the environment creates jobs, it can make money, and it doesn't have to be expensive!"

Schmid's balcony explosion has led to several awards: apart from the *Global Energy Award,* in 2003 Kompogas was also awarded the Swiss and European Solar Prize. "This is important for us," says Schmid. "Conservative municipalities are more eager to work with us when they hear we have received an international award!"

Walter Schmid tanks up his car at a Kompogas filling station.

Schmid inspires visitors to an information centre with enthusiasm for his concept.

PHOTOVOLTAICS

The power of art

Roland Kormann and the solar sail

In the municipality of Münsingen near Berne, a giant solar sail is producing solar energy.

Passengers on the train from Berne to Thun rub their eyes in amazement at the sight of the Münsingen psychiatric clinic. In the middle of a green meadow, a giant sail reaches towards the sky, though there is no sign of a ship and Lake Thun is miles away. The thing that amazes passengers is the Münsingen Solarsail, a 22-metre high photovoltaic power plant.

A symbol. "This combination of a power plant and a work of art is intended to highlight the benefits of renewable energy to residents and those passing through," says Roland Kormann, president of Münsingen's Solarsail Society. The idea came from Kormann's son Stephan and Bernese architect Peter Schürch. "The elegant shape of the sail is a metaphor for movement and lightness. It stands as a symbol for the sympathetic treatment of the fundamentals of our lives."

The initiator of the project is the Münsingen psychiatric clinic, whose administrative director was Roland Kormann until his retirement at the end of 2003. Since 1998, the clinic has had an environmental concept for all areas, such as care, sheltered workshops and agriculture. The municipality of Münsingen supported the project with a generous grant. The regional centre in the Aare valley is very active in the areas of energy and the environment. In 1997 it received the *Veloville* (bicycle town) award and has been designated an *Energy Town* (see box). The Swiss Federal Office of Energy, the canton of Berne and 80 companies, organisations and individuals also contributed to the costs of CHF 300,000.

A spectacle. The Solarsail consists of hundreds of solar cells. They collect the sunlight and produce about 6500 kWh of electricity per year. At midday the glass panels are a shimmering silver and at sunset they reflect the dark blue of the evening sky: a breathtaking spectacle!

The mast consists of three steel tubes held together by plates. The sail has a surface area of 90 m^2. It is secured to a curved tube attached to the mast and a horizontal boom at the bottom, with flexible steel cables supporting the photovoltaic elements. This gives the sail a curved shape capable of withstanding any storm.

No charge. The panels are fibreglass laminates. The solar cells are bonded to the glass panels using a special laminating process. The monocrystalline cells have a comparatively high efficiency. The modules are connected in series; two DC/AC inverters convert the DC current which is generated as alternating current. The output of the plant is 8.2 kW.

The plant is operated by the Solarsail Society. "Thanks to the 100% financing we haven't had any capital costs," says Stephan Kormann. The solar electricity is virtually free, though upkeep, maintenance and insurance still have to be financed. "This is why we sell the electricity to the Münsingen municipality's eco-power network." Since 1999 well over 30,000 kWh have been generated.

The awards. The Solarsail has won a number of awards, including the *special eta prize* from the Swiss electricity industry and the *Design Award* from the International Energy Agency (IEA). The plant also bears the Swiss eco-power label *naturemade star.*

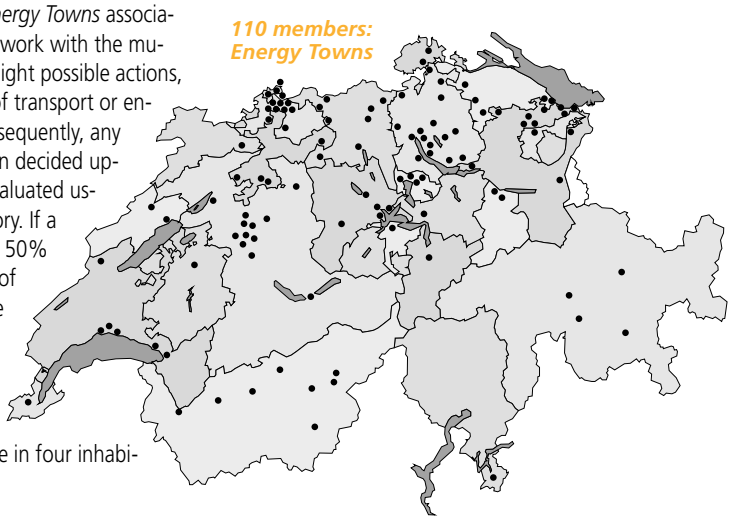
"The electricity produced is important because even the production of small amounts of electricity makes a contribution to sustainable energy production," says Stephan Kormann. The symbolic effect is key. "This beautiful plant demonstrates that forward-looking technologies can be integrated attractively everywhere – even in works of art."

Swiss Energy Towns

The Energy Towns programme supports the Confederation's energy goals and stimulates investment.

The focal point is the reduction of fossil fuel consumption and the use of renewable energy in the public sector. Every municipality can become a member of the *Energy Towns* association. External consultants work with the municipal authorities to highlight possible actions, for example in the areas of transport or energy use in buildings. Subsequently, any measures which have been decided upon or implemented are evaluated using a standardised inventory. If a community scores at least 50% of the maximum number of points, it can apply for the label. The progress of the measures is checked periodically. More than 110 communities have been awarded the label and one in four inhabitants of Switzerland now lives in an Energy Town. Every year electricity consumption is being reduced by 615 million kWh and CO_2 emissions are down by 238,000 tonnes. With a total budget of CHF 2.5 million, the programme stimulates investment of CHF 40 million and secures 400 jobs.

110 members: Energy Towns



GEOTHERMALS

The energy within

Markus O. Häring

An indigenous new source of energy is to be utilised in Basle

In Basle the depth reading is "2755 metres". This is the depth reached by the exploratory drill of the Deep Heat Mining (DHM) project. This is an ambitious project in the area of deep geothermals, which began in 1996 in Otterbach/Kleinhüningen, the port of Basle. The objective: environmentally friendly use of the earth's heat by converting it into thermal and electrical energy in a geothermal power plant on the surface. "With some optimism, operations could start at the end of 2009," says Markus O. Häring, the manager of the Basle project and director of the Swiss company Geothermal Explorers Ltd., based in Steinmaur.

Conditions. The principle of DHM or "hot, fissured rock" consists of setting up a heat exchanger at great depth in firm, deliberately fissured rock. In Basle, the borehole should reach a depth of 5000 metres. Cold water is injected under high pressure and conveyed to a point at which the rock is at temperatures of about 200°C. The water pressure opens up the existing fissures in the rock. The water circulates in the reservoir which is created, is heated up and brought back through one or more boreholes, termed production boreholes. The water has to be kept under pressure so it does not vaporise at such high temperatures. Back on the surface its heat content is delivered to a second circuit and converted to electricity and process heat in the geothermal power plant using a steam turbine and a generator. Thus houses in the locality can be supplied with both power and heat.

"The characteristics of the granite which occurs here are excellent," enthuses Markus O. Häring. He adds: "The quality of the rock is not the only condition for a project of this size. In the present case, an existing district heating plant and the political will which was present probably played an even more important role". The company *Industrielle Werke Basel* have the necessary network and the government of the canton of Basle City is prioritising environment-friendly energy supply projects. In August 2003 the cantonal executive approved the DHM project and proposed an investment loan of CHF 40 million (€ 26 million). This is supported unanimously by the energy commission of the cantonal parliament and will be voted on in the June 2004 session. The amount corresponds to half of the total investment of CHF 80 million. The other half of the budget is devoted to the construction of the geothermal power plant and the completion of the distribution network.

The Basle deep-drilling rig

"At the drill head we are expecting 30 MW thermal," states Markus O. Häring. Energy production on the surface will be 20 MW thermal and 4 MW electrical, so it will be possible to supply 5000 households in the Basle region with heat and power. "We will need about 1 MW of electricity to operate the system, so we will be able to feed 3 MW into the grid," calculates the project manager.

Prospects. The next steps involve sinking three boreholes to a depth of 5000 metres. "As soon as the loans are agreed, we shall begin to drill the first deep borehole." The Director of Geothermal Explorers Ltd. expects this borehole to be ready in January 2005 "with a bit of luck" and in operation by early 2007. The Basle project has unfortunately been somewhat delayed due to the lack of support from the Confederation. Parliament has not yet dealt with a parliamentary proposal for the promotion of geothermal heat and power generation, even though this is an indigenous, clean, virtually inexhaustible source of energy, which is independent of the time of day, the seasons and the weather. It can be regulated according to demand, needs little space and has hardly any environmental impact. An annual reduction in CO_2 output of 40,000 tonnes is in prospect for Switzerland.

In the medium term, the world's dependence on fossil fuels and nuclear energy could be considerably reduced. Switzerland could export an advanced technology and high-grade know-how. Europe is already committing itself to deep geothermals with the construction of the plant at Soultz-sous-Forêts in Alsace, which will come onstream in the course of 2004. "After Basle, we are hoping to implement a whole series of projects; Geneva has already expressed its interest and designated a site," announces François-David Vuataz, geothermals project manager and senior assistant at the University of Neuenburg, vice-president of the Swiss Union for Geothermals and member of the DHM Consortium project committee.

The first deep geothermal project in Basle will produce primarily thermal energy, "which will allow us to demonstrate its feasibility". In the future, however, the focus will be on electricity production, "thereby eliminating the distribution problems associated with the locality," stresses Markus O. Häring, who refers to numerous utility providers and cities which are interested in DHM.

ZURICH AIRPORT

Heating and cooling using thermal piles

Markus Hubbuch

In the new docking building at Zurich airport, foundation piles are being used to provide energy: a substantial proportion of the heating and cooling requirements is being met by using the ground as a heat sink.

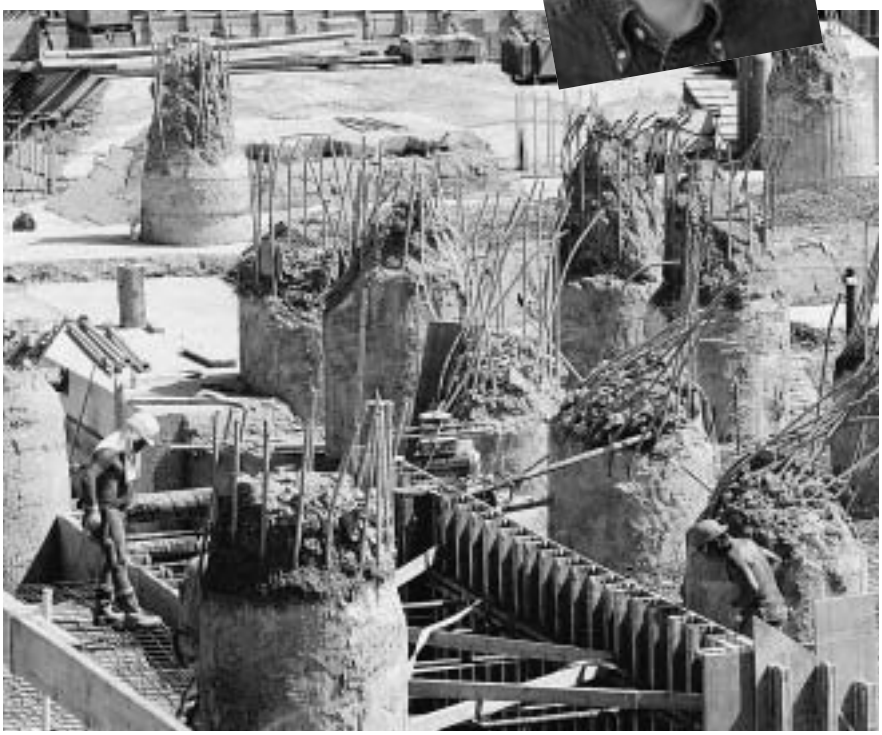
Because of the poor subsoil, Zurich Airport's Dock E (formerly *Midfield*), which was opened last autumn, is built on pile foundations. These columnar supports of reinforced concrete extend down to a depth of 30 metres. Only at this depth does the moraine provide a stable substrate.

Recovering energy. The unfavourable geological conditions, however, were also an opportunity for a trailblazing energy project: the foundation piles are also being used to recover energy. They are equipped with plastic tubes in which a mixture of water and glycol circulates. Warmth for heating is extracted from the ground in winter by this liquid. Conversely, in the summer the system is used to cool the building by conducting excess heat into the ground.

"We provisionally expect to cover 60 to 70 percent of heating and cooling requirements using renewable energy," states Markus Hubbuch. When he was designing the energy pile system, he was employed by the engineering company *Amstein + Walthert AG* in Zurich. Within ARGE ZAYETTA, the general design consortium for the *Midfield* dock, this company was responsible for total design of building services engineering.

Today, Hubbuch is the Professor for Energy and Building Services Engineering at the University of Wädenswil, where he also heads the Institute for Facility Management. "Thanks to the energy piles and better insulation, energy consumption per square metre of the surface area of Dock E is two to three times less than for the other terminals at Zurich airport," calculates Hubbuch.

Economical. The use of energy piles is a voluntary measure by the client. However, the additional investment of CHF 970,000 is worthwhile, as it reduces annual operating costs by CHF 94,000; the net annual benefit – including depreciation – is therefore CHF 16,000. This figure assumes a write-off period of 30 years, an interest rate of 5.5 percent and an energy price of CHF 0.08 per kWh of heat and CHF 0.166 per kWh of electricity.



The Zurich "energy piles"

Although it is not the first application of energy piles, the Dock E system breaks new frontiers, firstly due to its size: the dock building is 500 m long, 34 m wide and 21 m high. Of the 440 piles, 310 are used for heat transfer.

Preparing the inserts for the piles in the factory meant that the on-site welding work on the plastic pipes could be reduced to a minimum. Thus the tight schedule for the construction work could be complied with and the required high quality levels could be assured.

Measurements. With a view to optimal design, specialists from the EPF Lausanne used probes to measure the thermal conductivity of the subsoil on site and then carried out detailed simulations.

The Swiss Federal Office of Energy provided financial support for this preliminary work and therefore made a critical contribution to making this system a reality. It will now pay for a two-year measurement project, allowing the performance of the system to be examined in detail. The project will be implemented by the *Scuola Universitaria Professionale della Svizzera Italiana* in cooperation with *Amstein + Walthert* and the University of Wädenswil.

A yearly cycle

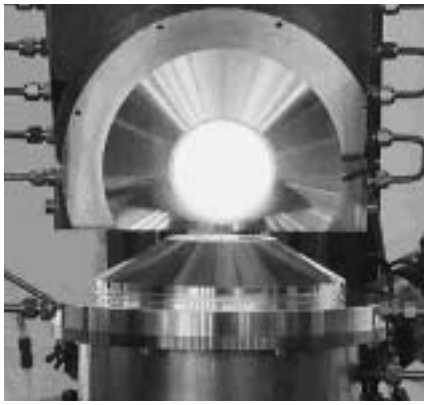
In winter exhaust heat is primarily recovered from the circulating air circuit in Dock E. If this is not sufficient to cover heating requirements, the energy piles come into play: the liquid used to carry heat emerges from the pipe manifolds at approximately 8°C (about 4° below the soil temperature); it is cooled by a few degrees in a heat pump, delivering heat to the heating system, and is then fed back to the manifolds, where it warms up again to about 8°C – and the cycle begins again. Additional heat supplied from conventional external sources is only required on very cold days.

In summer the relatively cold liquid is used to cool the circulating air circuit. It then transfers the heat to the ground via the energy piles. The electricity savings compared with cooling using chiller units offset the power consumption of the heat pump in winter. In summer, only a few peak situations require the use of the heat pump in cooling mode for additional cooling of the circulating air. Then the outside air for the fresh-air installations is cooled down in summer by chiller units to approximately 19°C.

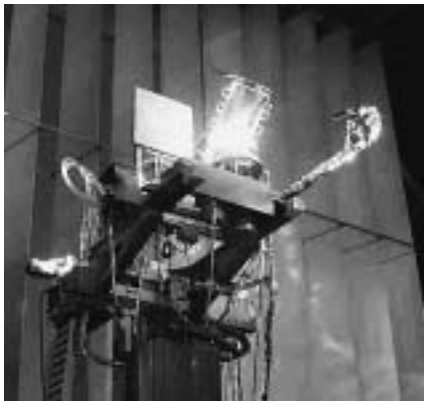
HYDROGEN

Solar sandwich

The solar "oven" at the Paul Scherrer Institute in Villigen



The opening of the solar reactor after an experiment



Experiment rig in the solar oven

Swiss research groups in the vanguard of developments in hydrogen electrolysis

Hydrogen is generally regarded as the most promising substitute for fossil fuels. But future large-scale use of hydrogen as a fuel will only be feasible if it can be produced on a sustainable basis. Swiss research is pursuing two alternative approaches to hydrogen generation using solar energy.

Tandem cell. Researchers at the Federal Institute of Technology in Lausanne (EPFL) and the University of Geneva have collaborated to develop a solar cell that produces hydrogen. "Our technology promises higher efficiency and lower cost than the conventional 'brute force' method in which solar electricity drives an electrolysis unit," declares Michael Grätzel, Head of the Laboratory for Photonics and Interfaces at the EPFL.

The new solar cell consists of a sandwich of two light-absorbing layers, hence the name "tandem cell". The upper part absorbs the blue component of sunlight, whose energy is used to oxidize water. In the first half of the reaction, oxygen ions are split off from the water.

In the other half, the remaining hydrogen ions are reduced to form hydrogen gas. The electricity needed is generated in the lower part of the sandwich. This consists in turn of a dye cell to absorb the red and green components of the sunlight.

Jan Augustynski and his team at the Institute of Chemistry at Geneva University have developed the vital component needed for the cell: a thin translucent film consisting of billions of minute particles (so-called nanocrystals) of the semiconductor material tungsten-oxide. The tungsten film forms the photo electrode absorbing the blue sunlight in the upper part.

The new tungsten film enables the production of tandem cells that store 5 to 6 percent of the incident sunlight in the form of hydrogen. This is a major advance compared to earlier technologies. The process is patented, and is to be developed in collaboration with an English company.

Moreover, to increase efficiency, new materials are being tried to accelerate the chemical processes taking place in the electrodes. Water, for example, can be electrolysed three-times more efficiently using a silver-chloride electrode in which gold particles of several nanometers diameter are dispersed – the crux of research by Antonio Currao and Gion Calzaferri at the Department of Chemistry and Biochemistry at Berne University.

Solar inferno. The Paul Scherrer Institute in Villigen (PSI) is pinning its hopes on the reaction between zinc and water vapour. The final products being simply hydrogen and zinc oxide. The zinc oxide can be converted back to metallic zinc in a solar crucible, and the cycle begun anew. As in the tandem cell, solar energy is again stored in the form of hydrogen, but in quite a different way.

To reduce the zinc oxide, mirrors direct sunlight onto the crucible to generate the temperature of 2000°C required. The "solar inferno" in the crucible makes heavy demands on the employed materials technology. Says Robert Palumbo, Head of the Laboratory for Solar Technology: "When carbon is injected into the zinc oxide, pure zinc is obtained at a much lower temperature of 1200°C. We are studying this variant at PSI within an international project." Though the process is no longer CO_2-free, the prospects of market maturity are much better in the middle term.

Eco Marathon hydrogen car

Last year, a hydrogen PAC (French abbreviation for "pile à combustible", or fuel cell) car took part for the first time in the Shell Eco Marathon at Nogaro in Southern France. The Federal Institute of Technology in Zurich developed the car in collaboration with the Paul Scherrer Institute and the University of Valencienne.

The car uses a fuel cell to convert hydrogen into electricity to power its electric motor. Although this ultra-light, single-seater vehicle carries only 15 grams of hydrogen in its metal hydride tank, it is enough to travel 90 km (equivalent to 1500 km on 1 litre of petrol). Eco Marathon's benchmark is to cover 25 km at an average speed equalling or exceeding 30 km/h with rock-bottom fuel consumption.

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