Cleantech ALPS

Western Switzerland Cleantech Cluster

Small-scale hydropower in Switzerland :

a leading-edge industrial sector

CleantechAlps is an initiative of the Cantons of Bern, Fribourg, Vaud, Valais, Neuchâtel, Geneva and Jura. Supported by the SECO under the New Regional Policy (NRP).

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Summary

Editorial

An expert talks about...

Small-scale hydropower in Switzerland : a leading-edge industrial sector

« Small-scale hydropower is a key economic sector for the 2050 energy strategy. »

Editorial

A little-know sector with a tremendous potential

In this new publication, CleantechAlps, the gateway to clean technologies, turns the spotlight onto small-scale hydropower. This is a key economic sector for the 2050 energy strategy. Moreover, it exploits one of Switzerland's only two undisputed energy resources, namely water (the other being biomass). Hydropower is also the reason for the high proportion of low-carbon electrical energy in Switzerland's energy mix. Small-scale hydropower contributes to this to the best of its ability.

Over the centuries, a wealth of industrial and academic expertise has been built up around this resource. We recently produced a study focusing on the potential and the players involved in the treatment and distribution of drinking water and also the treatment of waste water (download available from www.cleantech-alps.com/study). With this study of small-scale hydropower, CleantechAlps and its partners take you behind the scenes in a little-known industrial sector that has tremendous potential for development. We hope that you will find the information in this document useful and that it will help to make this sector and its potential better known.

Hydropower accounts for almost 60% of Swiss electricity generation. With its 100 years of know-how, it is an example of a traditional sector that is constantly reinventing itself, as you will see from the next few pages.

We hope you will find this study an interesting read!

Eric Plan
Chef Operating Officer of CleantechAlps

An expert talks about...

« Integration into existing infrastructures represents strong development potential for small-scale hydropower in Switzerland. »

By Cécile Münch-Alligné, professor of hydropower engineering at the HES-SO Valais-Wallis

> "Small-scale hydroelectricity contributes to maintaining and creating local employement."

The hydropower situation

Taken together, the sources of renewable energy, i.e. modern and traditional biomass, hydroelectricity, geothermal energy, wind power, solar power and biofuels represent 19% of the world's energy consumption[1]. Among these, hydropower, small-scale and large-scale, is one of the main sources. With an installed capacity of 990 GW worldwide, it produced 3,700 TWh of electricity in 2012. This represents more than 67% of the global installed capacity from renewable sources and 3.7% of the world's energy consumption. China, Brazil, the United States, Canada and Russia alone account for more than 52% of the world's hydroelectric installed capacity (figure 1).

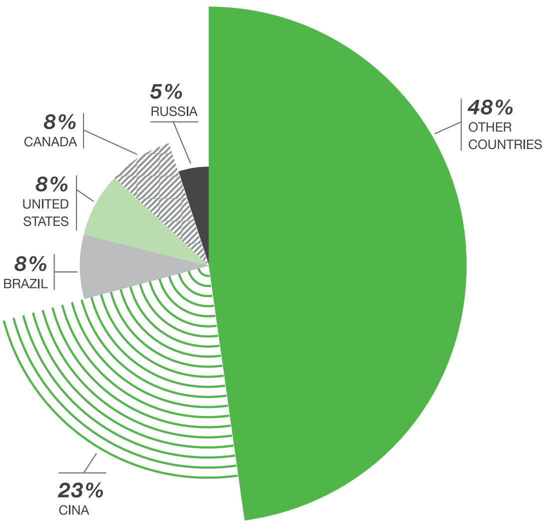

Figure 1 : Distribution of the world's hydroelectric installed capacity in 2012[1].

In 2012, 30 GW of hydroelectric capacity was added, more than half in China. With 229 GW installed capacity and 20.3 GW storage capacity, China continues to break the records. In 2013, Francis turbines, the most powerful in the world producing more than 800 MW per unit, were installed in the underground hydroelectric plant of Xiangjiaba.

In Switzerland, an average of 36,000 GWh of hydroelectricity is produced per annum, which represents more than 55% of the country's electricity production. As part of the Energy Strategy 2050, the Federal Council wants to increase the proportion of hydropower in Switzerland's future electricity provision. The aim is to see an increase of 2,000 GWh by 2030 and of 4,000 GWh by 2050[2].

A source of renewable energy

Hydroelectricity is an inexhaustible source of energy, using the terrestrial part of the water cycle, i.e. the water flow between the point it comes to earth as precipitation to the point it flows back into the sea. Moreover, hydroelectricity does not depend on any form of combustion, and in particular does not emit carbon dioxide. This form of energy production therefore respects the environment. Although the implementation of hydroelectric facilities can raise certain problems, compliance with the environmental protection laws and various technical solutions enable the impact on the natural world to be limited. In addition to being a source of renewable energy, small-scale hydroelectricity offers the possibility of decentralised electricity production.

The installation of small plants in rural areas provides electricity for people who otherwise would not to this day have access. In our part of the world, small-scale hydroelectricity contributes to maintaining and creating local employment, especially in technical fields. This is particularly true in small mountain communities, where there are job opportunities in the monitoring and servicing of the installations, and where local civil engineering firms, turbine manufacturers and electricians can also be involved in their construction and maintenance. A small plant may also contribute to balancing the budgets of these municipalities by generating considerable additional resources, guaranteed over the long term.

The situation of small-scale hydropower

In 2012, the global installed capacity for small-scale hydropower was estimated at approximately 75 GW, which represents more than 7% of the total hydropower capacity. The global potential is estimated at 173 MW[3].

More than half of the capacity from small-scale hydroelectric plants is found in eastern Asia. The greatest potential is in China, where rural economic growth and government support has enabled small-scale hydropower to develop rapidly, supplying electricity to more than a quarter of the population. The rate of development of small plants in China is greater than in the fields of large-scale or medium-scale hydropower. The objective set by the government is to achieve an installed capacity of 93 GW by 2020.

In the European Union, which included 27 countries at the time (EU-27), small-scale hydropower produced 46 TWh in 2010, with an installed capacity of 13 GW from its 21,800 facilities[4]. This production level corresponds to an electricity supply to 13 million households. Between 2005 and 2020, the installed capacity is set to increase from 12.4 GW to 17.3 GW, with production rising from 42 TWh to 60 TWh, which represents growth of more than 40%. Italy is the main producer in this sector in Europe, followed by France, Germany and Spain (figure 2).

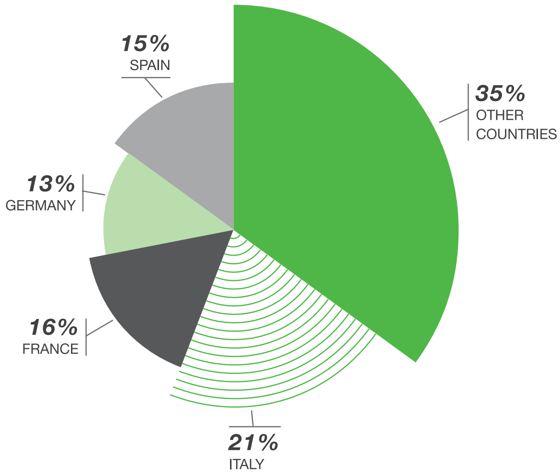

Figure 2 : Distribution of the installed capacity for small-scale hydropower in EU-27[4]

In Switzerland, small-scale hydropower represents 5% of the country's electricity production and 10% of its hydroelectric production (figure 3). The potential is estimated at 1,600 GWh per annum[5]. The development of small plants is encouraged by a cost-based feed-in tariff (FIT), which pays the difference between the production cost and the market price.

Installed electrical capacity (kW)	2010				
	Plants	MW	GWh / year	Total electricity production from hydro-power	Total electricity production
Below	~ 1'000	60	270	0.7%	0.4%
301-1'000	191	110	554	1.5%	0.8%
1'001-10'000	187	689	2'947	7.9%	4.4%
Above 10'00	169	12'882	33'730	89.9%	50.9%
Total till 10'000	1'378	859	3'770	10.1%	5.7%
Total hydropower	1'547	13'741	37'500	100.0%	56.6%

Figure 3 : Small-scale hydropower in Switzerland. Source : Crettenand, N. (2012) EPFL. Thesis No. 5356.

The development trends

Where does the water that drives the turbines of small-scale hydropower plants come from ? There are various possible sources: water courses, waste water, drinking water, reserved flow, irrigation water and snow cannons. Different types of plants have therefore been designed. The plants that offer the greatest benefits are those that are integrated into existing infrastructures, as they minimise the civil engineering-related costs and those of other aspects such as conduits, as well as the environmental impact. Some of the small-scale hydropower turbines are the same as those used in large-scale hydropower: Kaplan, Bulb, Francis, Deriaz or Pelton type turbines.

However, the strong potential for development, in particular the creation of concepts that are simple, low-cost, efficient, profitable and capable of integration into existing infrastructures with a low impact on the environment, requires the development of specific technologies. These are the lines along which cutting-edge institutes such as the HES-SO Valais-Wallis and the EPFL are carrying out their work.

These research teams are working on the development, for example, of axial turbines that function in high heads of water (figure 4) and "isokinetic" turbines that can recover the kinetic energy of tailraces. What is essential for the future of this sector is to be able to rely on medium-term development programmes, which take account of the market requirements from a very early stage, as has been done since 2010 with The Ark Energy programme.

In this context, in addition to the electromechanical components, the other line of development is in the integration of systems in the real environment. I am thinking here, for example, of the possibility of using micro-pump-storage plants for the local regulation of the electricity network, which might otherwise be disrupted by the intermittent injection of energy from renewable sources. Projects of this kind are currently being studied.

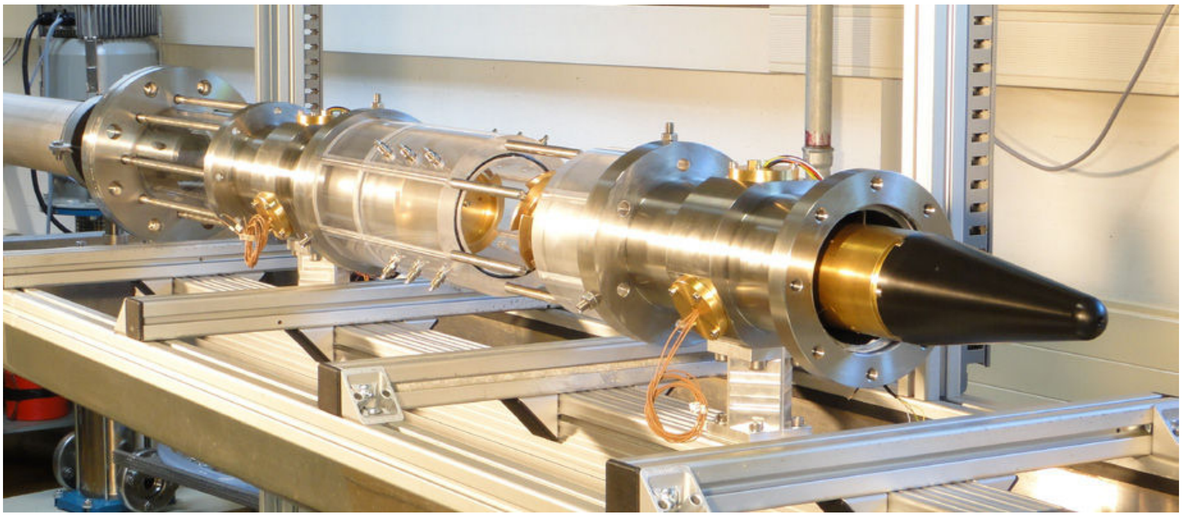

Figure 4: A counter-rotating micro-turbine developed at the HES-SO Valais-Wallis in collaboration with the EPFL.

1. REN21, 2013.

2. Swiss Federal Office of Energy, Le potentiel hydroélectrique de la Suisse, Potentiel de développement de la force hydraulique au titre de la stratégie énergétique 2050, Juin 2012 (The Potential for hydroelectricity in Switzerland – Potential for developing hydropower as part of the Energy Strategy 2050, June 2012).

3. World Small Hydropower Development Report 2013, WSHPDR 2013.

4. Stream Map for Small Hydropower for the EU-27 in the view of 2020 Target, ESHA 2012

5. « La petite hydraulique en Suisse: définition, technologies et perspectives » (Small-scale hydropower in Switzerland: definition, technologies and perspectives), A. Choulot. Bulletin ElectroSuisse 2, 2014.

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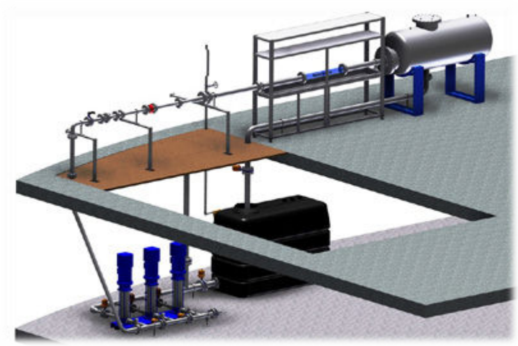
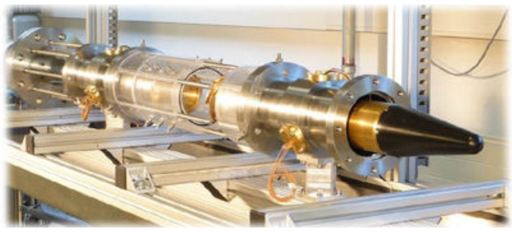
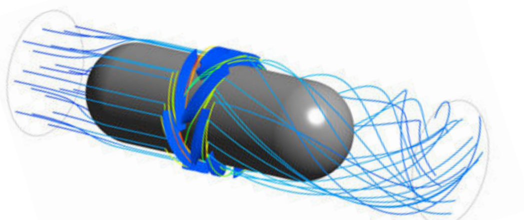


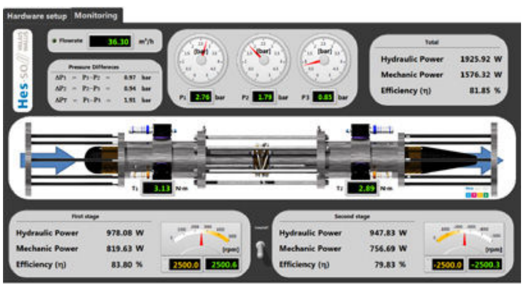
Hydraulic Test rig for small-hydro applications



Counter-rotating micro-hydro turbine - Bulb version



Numerical simulation of flow into a counter-rotating microturbine



Labview interface for the monitoring of the microturbine

In the heart of the Europe's water tower, the University of Applied Sciences of Western Switzerland – Sion (HES-SO // Valais-Wallis) dedicates an increasing part of its resources to renewable energies, in particular to hydroelectricity.

Applied Research and Development

Numerical simulations of flow and experimental measurements of different hydraulic systems of large- and small-power, in particular into the hydropower plants, starting from the water intake up to the tailrace channel: sand traps, penstocks and pipes, valves, turbines, pumps, diffusers:

- Flow analysis using numerical simulation
- Development of new technologies for small-hydro applications
- Design of electrical driving systems
- Performance measurements
- Monitoring

Teaching and Training

- Reinforcement of the teaching of our future bachelor engineers into the renewable energy domain, in particular in the hydroelectricity, within the new Energy and Environmental Engineering Degree Programme
- Short course in hydraulics
  www.weiterbildung-hydro.ch

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Interview …

« The greatest potential for innovation lies in integrating turbines into a larger context. »

By Christophe Bianchi, head of the Institute of Systems Engineering at the HES SO Valais-Wallis

" Small-scale hydropower can play a significant role in stabilising the network at local level. "

1. Mr Bianchi, small-scale hydropower has an impressive history. Do you see further potential for innovation in this field?

Certainly! We're currently seeing an increase in production on a local scale. The Alpine regions and cantons such as Valais have an added advantage in their geographic position and their topography. This makes them very important players in hydropower generation, both in Switzerland and in Europe.

As far as innovation is concerned, the fluctuations in the amounts of electricity generated from renewable sources mean that there is a major requirement for stabilisation of the electricity network. Small-scale hydropower has its own contribution to make, and can play a significant role in stabilising the network at local level. The greatest potential for innovation undoubtedly lies in integrating turbines into a larger context. This could involve installing robust, compact turbines into existing infrastructures whose primary role is not the generation of energy, for example by recovering the energy dissipated by pressure reducing valves in drinking-water networks.

2. What are the main specialisations involved in this sector, and what courses are offered by the HES-SO Valais-Wallis?

The HES-SO Valais-Wallis has two main degree programmes that cover small-scale hydropower. The first of these is Systems Engineering, which was established in 1988 and is concerned mainly with the development of new industrial products – which of course includes the new turbines.

The second degree programme, which was launched in autumn 2013, is called « Energy and Environmental Engineering ». The majors offered include Smart Grid and Renewable Energy, in line with the requirements of the market. These two degree programmes are complementary, so that they train people not only to develop new products but also, and above all, to integrate them. We are therefore training engineers, but also the specialists who will make use of new hydropower technologies.

We also want to establish a laboratory for small-scale hydropower to add to the mini-hydropower laboratory that we already have. This new laboratory will create a link with EPFL, which is very involved in this sector, becoming part of its new centre for large-scale hydropower at Sion. There are some valuable synergies that can be exploited.

3. Is it possible to talk of a revival in the hydropower sector, with a particular emphasis on small-scale hydropower?

It's not really a revival. The large-scale hydropower sector is in transition, with business models that are changing. Small-scale hydropower has been boosted by the political decisions that have been taken, and has been thrust into the limelight. Now, the hopes placed in it need to be turned into reality, and its potential needs to be confirmed.

Interview …

« Swiss enterprises are already in a position to supply reliable solutions. »

Patrick Hofer-Noser,
President of Cleantech Switzerland

“ Small-scale hydropower enjoys a maturity based on more than a century's experience. ”

1. Mr Hofer-Noser, Switzerland is known as the « water tower of Europe ». How is the country perceived in the small-scale hydropower sector ?

This industrial sector is well-established in Switzerland. It enjoys a maturity based on more than a century's experience. Switzerland is better known abroad for large-scale projects, but the context is currently changing rapidly. One thing is certain : thanks to the technologies currently under development, small-scale hydropower in Switzerland is ready to make its mark on these markets.

2. Hydropower is often not considered a « new » renewable energy; is it just semantics ?

Hydroelectricity is an « old » form of renewable energy. Before its use specifically for the production of electricity, it helped the Swiss valleys to establish industries such as mechanical engineering workshops, sawmills and other trades, which were powered by water wheels. The emergence of large-scale hydropower plants overshadowed the benefits of the decentralised use of water as a power source. As a renewable energy, hydroelectricity, small-scale and large-scale, will play a significant role in global energy production and the energy mix. While other countries are discovering small-scale hydropower as if it were a new technology, Swiss enterprises are already in a position to supply proven, reliable solutions for the exploitation of this « old » source of renewable energy.

3. We often hear that the internal market is THE major export market. Given this, access to this market and the confidence of its players are essential. Is this one of the reasons behind your partnership with CleantechAlps ?

Cleantech Switzerland is the official Swiss platform for export activities in the field of clean technologies. Our partnership with CleantechAlps, which represents us in Western Switzerland, works very well. Our common aim is to communicate a co-ordinated image of the cleantech scene to people abroad, in order to maximise the impact for Swiss enterprises. As regards the first part of your question, for many SMEs the Swiss market is an essential point of reference. However, export activities require an understanding of new cultures and different challenges – we can offer substantial support to SMEs, with our partners and with the external Swiss network that has strong local footholds in the countries in question.

Small-scale hydropower in Switzerland: a leading-edge industrial sector

1. Introduction

Renewable sources of energy for generating electricity are being promoted to an ever-increasing extent in Switzerland as in the rest of the world. The dramatic accident that occurred at the Fukushima nuclear power plant highlights the importance of diversifying the sources of electricity generation, in particular by making use of these new sources of energy. In Switzerland, the Federal Council is aiming to increase the generation of renewable energy by 26 TWh between now and 2050, a figure that includes energy from hydraulic sources. In 2011, the annual generation figure stood at 63 TWh, of which 34 TWh came from hydropower. The European Union's climate and energy package, launched in 2008, aims to combat climate change and establish a common energy policy that is more sustainable and lasting, with the « 3 x 20 » objective. Increasing the proportion of renewable energy sources in the European energy mix to 20% is one component of this. Within this context, the covenant of mayors[1] already draws together over 4000 municipalities, including 12 in Switzerland. These municipalities also have their own objectives concerning the development of renewable sources of energy.

Hydropower is one of the forms of renewable energy. All too often, we tend to forget it, focusing the debate on forms of renewable energy described as « new », such as solar photovoltaic, wind, or biomass. Over the entire generation process, hydropower is actually very efficient, as the graphic below shows.

Hydropower plants generate electricity with a high degree of technical efficiency (its yield is around 80%) and very few greenhouse gas emissions. The electrical energy generated during the lifespan of a hydropower station is approximately 170-280 times greater than the energy needed to build, maintain and demolish it. For wind farms, this ratio is about 20-35, for photovoltaic panels it is about 10-20, for nuclear power plants it is around 15 and for gas-fired (combined-cycle) power plants it is about 2-5. The greenhouse gas emissions from small-scale hydropower plants amount to about 10-13 gCO_2e/kWh, for wind power they are 9-10, for photovoltaic energy 32, for nuclear power 66 and for combined-cycle gas 440. Hydropower plants also contribute to local electricity generation and therefore increase the security of Switzerland's electricity supply.

Large-scale hydropower has been well developed technologically during the 20th century and this sector has a solid engineering basis. Its younger sibling, on the other hand, has been somewhat left behind until recently. This is because small-scale hydropower developed empirically and now needs further research and development so that the available potential can be exploited to the full.

It is not simply a scaled-down version of large-scale hydropower: the construction of small-scale hydropower plants is a completely separate specialism with its own particular expertise and features.

Hydropower plants: very efficient !

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Small-scale hydropower in Switzerland: a leading-edge industrial sector

2. Definition and current state

There is no universally-recognised definition of small-scale hydropower. A maximum installed capacity of 10 MW is the value most widely accepted, and is also the definition that features in the Swiss federal law on hydraulic power.

Small-scale hydropower can be subdivided into smaller categories, for example mini-hydropower with a maximum installed capacity of 1 MW and micro-hydropower with a maximum installed capacity of 100 kW. The term pico-hydropower is also used for a few watts or tens of watts of power. It is now an emerging sector, with the advent of smart water networks. These networks should eventually enable buildings to be supplied with electricity by turbining the water in their water systems. The Institute of Systems Engineering of the HES-SO Valais-Wallis is involved in this field (see portrait, p. 49).

This definition of small-scale hydropower, based on installed capacity, can be misleading, because it does not accurately reflect the difference between small- and large-scale hydropower. This is because power plants below 10 MW can be very different in their design and in the types of generation system used. As an example, the Seujet plant in Geneva has an installed capacity of 8.7 MW and took 8 years to build. The plant at Douve, near Leysin, has an installed capacity of 75 kW and was built off-site in 4 months and then installed at the site in 23 minutes.

For this reason, the Association des Usiniers Romands, an organisation for operators of small-scale hydropower plants in western Switzerland, defines a small-scale hydropower plant as a power plant that, for technical and economic reasons, cannot be a scaled-down version of a large power plant.

2.1 Some more definitions…

Via small-scale hydropower (SHP) the potential energy of water is transformed into mechanical or electrical energy. Figure 1 shows the main parts of an SHP plant that uses water abstraction. Water is drawn off at the water intake (❶). A sand trap (❷) is used to eliminate material that has passed through the screen at the water intake and would be harmful to the operation of the plant, such as sand or gravel (in relation to this, see the company portrait of Stahleinbau, p. 55). The headrace (❸) conveys the water into the forebay (❹). From this forebay, the water is under pressure and travels via the penstock or pressure shaft (❺) until it reaches the plant (❻). Once there, the water passes through the turbine and is then returned to the water course via a tailrace channel.

The installed capacity of an SHP plant depends mainly on the flow rate used and the available head. Although the turbine is the most important component, enabling the kinetic energy of the water to be transformed into rotational mechanical energy that can then be used to drive an electric generator or other machinery, the key to optimising the operation of the installation as a whole lies in managing information, from the water intake to the plant (with regard to this, see the company portrait of DPE Electrotechnique, p. 45). The turbines used include Pelton, Francis, Kaplan and diagonal turbines.

There are different types of SHP plants. Run-of-river plants turbine the water continuously when the flow rate is sufficient. Water is not abstracted from the watercourse. Water abstraction plants, like that shown in figure 1, on the other hand, abstract water which is turbined, and they must leave a minimum residual flow downstream of the water intake. Storage plants, such as the Cleuson-Dixence large-scale hydropower plant in Valais, have an upper reservoir that allows water to be stored and, in particular, allows electricity to be generated on demand. Pumped-storage plants have an upper and a lower reservoir, which enables them to pump water into the upper reservoir when there is excess electricity in the network (examples include the Nant-de-Drance plant under construction on the Franco-Swiss border near Chamonix, and the Linth Limmern plant at Glaris, another large-scale hydropower plant). These plants can generate electricity flexibly and will play an increasingly important role in managing the stability of the European electricity network.

The technology used in SHP plants encompasses a number of disciplines including mechanical engineering, civil engineering, electrical engineering, hydrology, geology, biology and environmental sciences. This last-named field is particularly important in reducing the adverse effects on the environment.

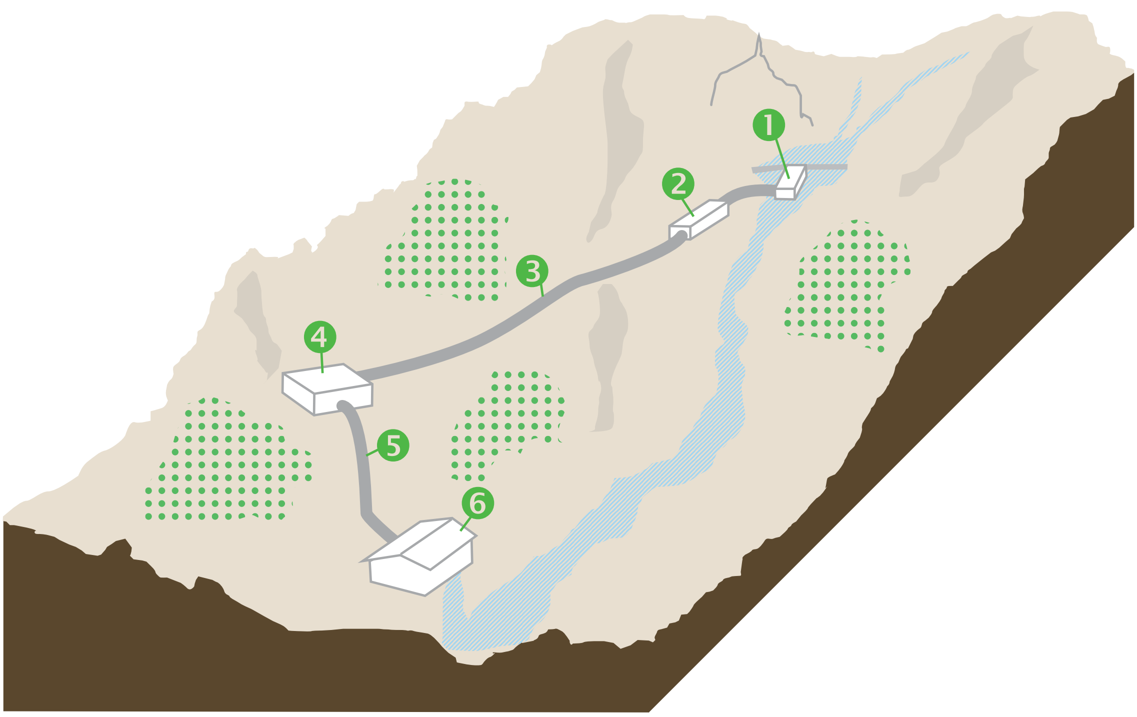


Figure 1: Main parts of a small-scale hydropower installation with water abstraction. Source: Andaroodi and Schleiss, 2005: 22

2. Definition and current state

2.2 Environmental impact

SHP plants have an impact on the environment, during both their construction and their operation. One of the main challenges in developing small-scale hydropower is to find the right balance between generating electricity and protecting the environment. It means maximising the generation of electricity while minimising disturbance to the fauna and flora originally found at the site, such as disruption of fish migration.

The effects of SHP systems on the environment are very specific to each site and depend on the type of SHP (run-of-river, abstraction, storage). In the case of a dam, the continuum of the watercourse is interrupted. This means that, for example, fish and other aquatic species can no longer travel downstream or upstream of the dam.

If adequate steps are taken, such as creating fish passages and choosing residual flow rates adapted to the site, the adverse effects of SHP plants on the environment can be minimised. Where old SHP plants or old weirs in watercourses are restored, the overall impact on the environment of a new SHP plant can even be positive, a fact that tends to be forgotten.

2.3 Switzerland's energy potential

In 2010, small-scale hydropower contributed 5.7% of the electricity generated in Switzerland, in other words, 3.8 TWh, with an installed capacity of 859 MW (Crettenand, 2012). Compared with other forms of renewable energy, excluding large-scale hydropower, it is by far the largest source of renewable power for electricity generation in Switzerland.

At the beginning of the 20th century, there were 178 SHP plants with an installed capacity ranging from 300 kW to 10 MW, and almost 7000 SHP plants with an installed capacity of less than 300 kW.

This latter group was reduced to about 700 units by the end of the 20th century, while the number of plants in the 300 kW-10 MW range more than doubled during the same period, reaching 445 units. This development is explained by the impact on cost of the construction of ever-greater numbers of ever-larger plants.

Thus, there are some old plants, with an installed capacity of less than 300 kW, which have now been abandoned. These could be brought back into service while keeping costs at a similar level to other technologies, such as solar photovoltaic energy.

2. Definition and current state

A potential of 1.3 TWh

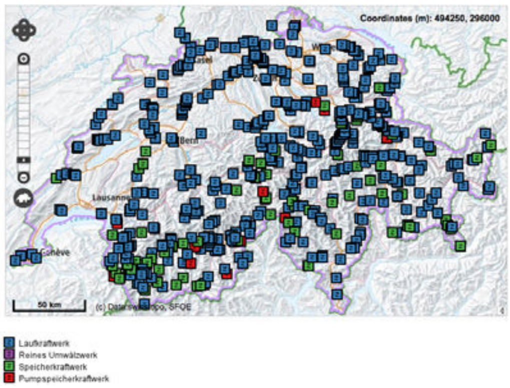
The potential of small-scale hydropower that could be realised between now and 2050 has been estimated as part of the 2050 Energy Strategy of the Swiss Federal Council. Under the present framework conditions, the potential that could still be exploited amounts to 1.3 TWh, which would lead to small-scale hydropower plants generating 5.1 TWh in 2050. If the economic framework conditions (via financial support, for example) and social framework conditions (acceptance of SHP plants by the community) were improved, but without any relaxation of the requirements in terms of protecting water and the environment, the potential that could still be exploited amounts to 1.6 TWh. This would enable SHP plants to generate a total of 5.4 TWh in 2050 (SFOE, 2012)[2].

Taking into consideration the cantons of western Switzerland only (French-speaking Switzerland and Bern), the realisable potential with improved framework conditions is greatest in Valais (300 GWh), followed by Bern (220 GWh) and Vaud (140 GWh). Fribourg and Neuchâtel have a low potential of 48 GW and 30 GWh respectively. The Jura and Geneva have a negligible potential. (SFOE, 2012)

A significant degree of potential is to be found within existing or planned infrastructures, such as networks for drinking water, waste water, irrigation and snowmaking.

SHP plants within such infrastructures allow value to be added to the operation of networks constructed for other purposes. They do not produce any adverse effects on the environment and their investment costs are low. A guide to the development of SHP within infrastructures has been produced by Mhylab and the European Small Hydropower Association (ESHA) (Mhylab and ESHA, 2010)[3]. A guide for municipalities, incorporating a ready-reckoner tool for estimating the cost-effectiveness of an SHP system, has also been published by BlueArk[4].

A comprehensive, interactive map



The Swiss Federal Office of Energy (SFOE) has listed the majority of Switzerland's hydroelectric power plants (with an installed capacity greater than 300 kW) on an interactive map. This map not only shows large hydropower plants and run-of-river plants, but also small hydropower plants, and provides useful details about them, including their generation figures and their sites. The impressive number of plants listed proves, once again, that Switzerland really is one of the water towers of Europe, and that the exploitation of this resource is based on a tried and tested industrial sector supported by some leading-edge research establishments such as the federal institutes of technology, the HES-SO and Mhylab.

Information

SuisseEnergie: a national support programme for SHP plants

The aim of SuisseEnergie's small hydropower plants programme is to exploit the existing development potential of small-scale hydropower plants which could achieve an output of one megawatt. It supports the production of brief analyses, has an informative and advisory role, and encourages networking among the different players – from the owners of the installations to fishing associations and environmental organisations, and including the authorities. The programme is hosted by Mhylab (Vaud).

Further information

2.4 Potential for technical developments

Research and development for SHP began only a few decades ago. The maturity of its older sibling might lead people to believe that SHP has very little development potential. In fact, this is far from being the case. The reason is that small-scale hydropower is not simply a product, but a technology that brings together several components such as pipes, turbines, alternators, etc. Each of these elements has a significant potential for development and improvement. However, optimisation makes sense only if its impact on the ecosystem over time can be measured. The maturity of this sector in Switzerland is precisely what provides a guarantee in this respect. As in any market for capital goods, a high degree of pressure on prices is evident in this sector. An analysis of the cost structure of an SHP system shows that a special effort has to be made to reduce generation costs. These costs represent from 9 to 30 euro cents/kWh in comparison with very low operating costs (Leutwiler, Bölli et al., 2011). It is essential to move towards standardisation to produce a significant effect on generation costs. R&D is often too expensive for SMEs and is therefore mainly carried out by large companies (ANDRITZ HYDRO, Alstom) or research bodies such as the HES-SO or Mhylab.

Competitive products

The major challenge for manufacturers and contractors is offering competitive products and services. In this respect, the Swiss SHP sector enjoys a strong position and a valuable advantage over the competition: its know-how combined with Switzerland's reputation for quality. This significantly increases the value perceived by the client, a perception further reinforced by the sector's long history, which adds to its credibility.

While the quality and reliability of Swiss equipment has enabled it to establish its pedigree, it is a creative approach to design that is beginning to reinvigorate this sector, with solutions that should rapidly attract interest from outside Switzerland. The integration of new information and communication technologies (ICT), for functions such as remote management, is adding a whole new dimension to this field.

The importance of storage

With the development of intermittent renewable energy resources, such as wind power or photovoltaic cells, storage and flexible generation are becoming increasingly important in the electricity sector. With storage and pumped-storage power plants, hydropower can help to solve part of the equation related to energy storage and flexible generation.

Some attractive business opportunities are emerging for small-scale storage and pumped-storage power plants. The market is eagerly awaiting the advent of small turbines that are suitable for pumped-storage systems. EPFL, which is constantly monitoring development trends, has already produced a detailed study of the subject in a doctoral thesis by one of its students (Crettenand, 2012)[5]. Switzerland is at the cutting edge of developments, with the work of people such as Professor Cécile Münch of the HES-SO Valais-Wallis (see p. 6).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2.5 Barriers to development and possible solutions

Generally, there are three main types of barrier to the development of SHP plants, namely economic, environmental/social, and institutional.

From an economic standpoint, the cost of SHP systems is generally higher than the cost of large-scale hydropower, nuclear and gas-powered plants. If the laws of the market are the sole consideration, then SHP plants should not be developed as a priority. If, on the other hand, external costs (such as the pollution produced by fossil fuel plants, the consequences of accidents etc.) are taken into account, and if there is a political will to develop renewable sources of energy such as SHP, then some financial measures can be taken.

In Switzerland, the introduction of the cost-based feed-in tariff (FIT) in 2009 is one example of such a measure. The electricity injected into the network by an SHP system receiving the FIT is paid for at a fixed price per kWh for 20 years. The FIT is regularly revised to ensure that it is consistent with changes in the energy sector. Similar incentive measures exist in Europe and throughout the world, and will doubtless play a decisive role in the future expansion of this sector.

2. Definition and current state

Opposition to projects

The environmental and social barriers mainly concern opposition to projects. Appeals against projects can be justified if these projects do not take sufficient account of the ecological and environmental dimensions (such as migration of fish). Some technical measures can be taken to reduce these barriers, but they must remain financially reasonable in order to allow the projects to be implemented. The great challenge in this respect is to be able to discuss the various aspects openly whilst remaining aware of people's sensitivities. The Swiss players have developed a very diplomatic approach to the subject, which is undoubtedly an asset in export markets.

The development of SHP plants in Switzerland involves a debate within society as to which watercourses will be affected by electricity generation and to what extent. From an impartial standpoint, it seems logical that, for the purpose of providing energy, the potential of each resource within the energy mix should be exploited as fully as possible.

Thus, each resource would contribute as far as possible to the country's electricity supply, and do so even though some detractors argue that SHP makes only a small contribution (5 to 7%) towards replacing nuclear generation. The SHP plants are nevertheless among the solutions to be developed as part of the Federal Council's new energy policy. In order to increase the support for SHP plants and reduce the opposition, the SHP projects that are feasible from a technical, economic and ecological standpoint need to be filtered out very early on (in the initial investigatory phase).

Filters can be developed for each project (as in Valais with the Giganat[6] tool) or within overall plans for the whole canton (as in Bern, with its water use strategy[7]). It means using development planning tools, which involves the institutional framework.

Legislative complexity

The institutional barriers arise mainly because of the complexity of the framework that governs this field. In Switzerland, this framework is determined by regulations within the water and energy sectors (which includes electricity), and also by regulations related to the environment and to development planning. In addition, these regulations are divided between the federal, cantonal and municipal levels. For example, the FIT is regulated at federal level, franchises to use water for generating hydroelectricity at cantonal or municipal level, while construction permits are regulated at municipal level. Part of the Federal Council's action plan, via its 2050 energy strategy, is to simplify and harmonise the administrative procedures that result from this complex institutional framework.

Certain measures can be implemented quickly and without any change in the law. These include, for example, establishing :

- the filters mentioned above ;
- a single point of contact for SHP plants (where cantons do not yet have one) ;
- a checklist for project promoters ;
- expanding the Swiss Federal Office of Energy's programme of support for SHP plants.

Other measures require changes in the law and will therefore take longer to implement. They will doubtless also be more controversial. These measures include, for example, harmonising procedures throughout the whole country, and grouping together all the applications for planning permission, franchises and allocations of financial support in a single application. It should also be possible to group together, in a single procedure, applications for several SHP plants on the same watercourse. It would also involve finding solutions for sharing out the exploitation of catchment areas between large hydropower plants and SHP plants, adopting a pragmatic approach that would allow large, high-output installations to be exploited to their fullest capacity (residual flow, raising the height of the dam, etc.) and keep some catchment areas free of new installations.

To summarise, if support via the FIT is continued, the main challenge in developing SHP systems in Switzerland is the understanding between the parties advocating the generation of hydraulic energy and those who want to protect the environment. In this matter, dialogue is essential in order to reach a consensus that is acceptable to all parties.

3. The value chain and the main players in small-scale hydropower

Given the information presented up to this point, and with a view to ensuring that the SHP sector thrives in the long term, we will now analyse the composition of the economic fabric, list the players and examine their position in the value chain.

True to the CleantechAlps philosophy and role, we have adopted an approach that focuses on the technology players. This choice was dictated by the observation that one factor in the growth of liberal societies is the close link with innovation, which itself is closely linked to the technology players.

The second reason for focusing our approach on these players in particular is that technology providers represent precisely the point of introduction of these new technologies into the value chains. We have therefore chosen this option as the basis for figure 2 (p. 23), in which we zoom in on the major Swiss technology players. This view is supplemented, at the end of the study, by a (non-exhaustive) overall geographic view of the major players identified, to whom we must of course add the R&D institutes, electricity companies, and the engineering firms that specialise in this sector (p. 38-39).

As described above, a small-scale hydropower plant consists of numerous components. These components concern civil engineering (water intake, dam, fish passage, sand trap, pipe/channel, reservoir, buildings) or electromechanical engineering (turbine, alternator, transformer, control and management centre).

The value chain in small-scale hydropower (see figure 2) consists of the R&D, followed by the engineering stage that aims to further develop the plans (design, submission of planning applications for public scrutiny, etc.). The different components are then manufactured, installed or built on-site. The chain ends with the operation of the plant, which includes, in particular, the management and maintenance of the entire installation.

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3.1 The main players in Switzerland

The main players are shown in figure 2 with an indication, for each one, as to whether their offer covers civil engineering, electromechanical engineering, or environmental consultancy activities.

Engineering covers engineering firms, and the names of the largest firms involved with SHP systems are included, along with the names of hydropower generation companies that have in-house engineering capacity. Usually, some civil engineering components (such as the construction of the water intake and the building for the generating plant) are produced by local civil engineering companies.

Potential for professionalisation among micro power plants

At the moment, the majority of SHP plants are constructed either by electricity companies and/or municipalities, or by private players, particularly in the case of mini or micro power plants. It may be that the construction of these plants is more a product of DIY than of engineering work compliant with the rules of good practice in the field. Thus, there is clear scope for improvement in this sector. The potential for « professionalising » these activities is significant and some players, such as DransEnergie or Gasa Hydro, have already established a presence in this particular niche.

Even for small capacities, it is important to provide good technical quality and therefore good energy yields so that the hydroelectric potential can be exploited as much as possible. Mini- and micro-plants can generate as much power as wind turbines or small arrays of photovoltaic panels, with the advantage of continuous generation (because there is a constant flow of water, on a seasonal basis at least). When looking at the yield of these units, one has to bear in mind the environment and the context of the new SHP plant. This is particularly the case for installations in emerging countries, where yield is not necessarily accorded the same weight among the decision-making criteria and where maintenance costs are insignificant compared with the size of the initial investment.

SHP plants are operated either by large regional or national electricity companies, or by municipalities or their local public limited companies. No list of this last group has been produced as part of this study. There are over 800 players involved in the generation and distribution of electricity in Switzerland, with new entities being created almost every day, specifically to manage this type of small hydropower plant. These players include FMV, HYDRO Exploitation, Greenwatt, Romande Energie Renouvelable, DransEnergie, BKW, Alpiq, Axpo, EnAlpin, Premel, and Repower.

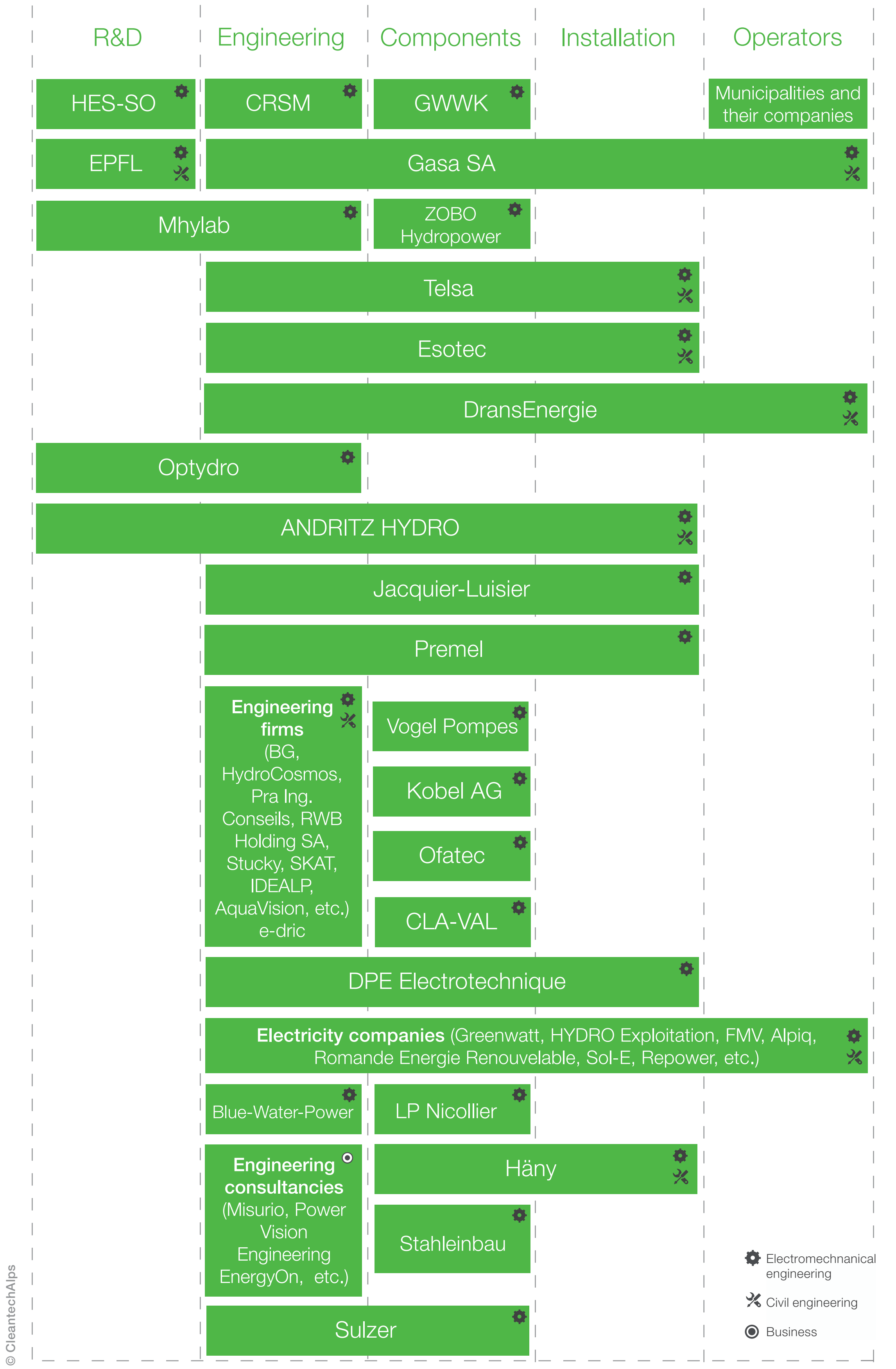

Figure 2: Distribution of technology players along the SHP value chain

3. The value chain and the main players in small-scale hydropower

The Swiss environment is therefore definitely more complex. As a comparison, in the Rhône-Alpes region, which has the same catchment population, there is just one player !

This «technology» value chain forms part of an environment with multiple players, who actively participate in the debate on SHP in Switzerland. The ecosystem includes the following bodies:

- NGOs in favour of developing SHP such as the federation of hydropower operators in western Switzerland (ADUR);
- environmental NGOs, such as Pro Natura and WWF;
- exchange platforms based around subjects related to SHP, such as Agenda 21 for water[8] or InfoEnergie, which has regional offices throughout Switzerland (see boxed text, p. 18);
- banks, for joint funding of the SHP plants;
- insurance companies, to insure SHP plants against certain risks;
- and lastly, Elcom, Switzerland's federal regulatory body for the electricity sector.

3.2 Specific areas of expertise

As regards R&D, Mhylab (see portrait, p. 52) has specific areas of expertise in relation to electromechanical components, particularly turbines. Several research programmes have enabled it to develop new turbines, and also to adapt turbines originally developed for large hydropower plants for use in small-scale plants. This expertise is already in demand for projects outside Switzerland.

Within the framework of Energypolis, the experimental research platform for energy at the EPFL Valais Wallis Campus, the HES-SO (see portrait, p. 49), in conjunction with EPFL, will pursue the development of hydropower machinery. It will place particular emphasis on small installations, incorporating research and test capabilities for turbines such as Pelton mini-turbines, micro-turbines with counter-rotating wheels, and "isokinetic" turbines.

As regards the evaluation of a site's hydrology, with a view to installing an SHP plant there in future, the company e-dric (see portrait, p. 47) is able to model the flow rates in a watercourse extremely accurately, using its Routing System tool. Other engineering firms have their own tools for assessing a site's potential.

Expertise in engineering firms and electricity companies

Engineering expertise is widely available among the different engineering firms and the regional and national electricity companies, and is an asset to the sector in Switzerland. A complete list of the players would be too long, but it is worth emphasising their diversity in terms of their size, and their distribution throughout Switzerland – which is, naturally, more dense in mountainous areas that are suitable for SHP plants.

There is a rich tapestry of players in this sector, covering the whole of Switzerland (see map of players, p. 38). Companies particularly active in this field include Stucky, e-dric, Mhylab, BKW, DransEnergie, CRSM, Entec, ITECO, DST Group, IM Maggia Engineering and Entegra, to name but a few.

Expertise in SMEs

The SHP sector in Switzerland owes its reputation and its solid foundations to the talent of skilled tradespeople. As far as electromechanical components are concerned, SMEs have developed particular expertise and are able to produce, for instance, high-quality turbines and electronic equipment. Such SMEs include, amongst others, Gasa Hydro, ZOBO Hydropower, DransEnergie, Telsa, GWWK (Genossenschaft WasserWirbel Kraftwerke), Esotec, Kobel, and Premel.

With regard to components, there is a distinction to be made between the developers of electrical or electronic equipment, and mechanical engineering workshops, such as Nicollier (Yvorne) or Jacquier-Luisier (Evionnaz), which machine turbines. Jacquier-Luisier (see portrait, p. 51) has developed a unique expertise, covering not only the machining of critical parts (Pelton wheels, for example), but also the production of the entire machine, including the frame and alignment of the components. As regards the control system and the manufacture of control panels, there is a broad range of expertise in the sector, particularly in players such as DransEnergie, Telsa, DPE Electrotechnique, Esotec, and Premel.

Some companies, such as Gasa Hydro or DransEnergie, have developed a number of competences and cover several segments of the value chain. They offer turnkey solutions and bring a special expertise to the implementation of installations, from beginning to end. This gives the implementation continuity and ensures a high degree of reliability.

Forces motrices de la Gougra SA

Navizence hydro power plant in Chippis

Built in 1908, the Navizence hydro power plant in Chippis, Valais, has been entirely rehabilitated between October 2010 and December 2013.

The seven old horizontal groups have been replaced by 3 new vertical Pelton units of 24.3 MW each.

The 3 new groups were built in the existing power plant. The works unfolded in three phases in order to limit the operation stops.

The Navizence power plant belongs to the Forces Motrices de la Gougra SA, the 5th Valais hydroelectric development in terms of production.

Supply, delivery, erection and commissioning of the 3 new groups including complete governor systems.

Quantity:	3 Units, 5 jets, vertical Pelton
Original Supplier:	Bell / Escher Wyss
Commissioning:	1908 / 1939 / 1950
Output old:	7 x 7 MW; 7 MVA (8.5 MVA)
Output new:	3 x 24 MW; 26.5 MVA
Speed new:	750 rpm

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3. The value chain and the main players in small-scale hydropower

Additional involvement as operators

These companies are also power plant operators, alongside municipal enterprises that are involved as operators only, and the large electricity companies. Being in control of the operation of the plants is a definite advantage for these companies and their clients, as it enables them to optimise maintenance and the manufacture of components for future installations. Thus, the circle is completed. In this sector, it is essential to be able to rely on these players, whose involvement spans the entire length of the value chain, rather than occurring at one particular point.

In Switzerland, the operators of hydropower plants have long experience of plant management and maintenance. Beyond their everyday political and economic concerns (adding value to the electricity generation, security of supply, the return of water rights to municipalities, etc.), the current technological challenge is to integrate new information and communication technologies into their services and infrastructures. In other words, adding enough of the necessary intelligence, at the right point, to facilitate remote management and maintenance. This includes, for example, alerts in the event of a malfunction, notifications about cleaning the water intake, and hydrological forecasts, which enable the planning of electricity generation to be optimised.


© Gasa

The leading export market is… the domestic market

Switzerland has cutting-edge competences that are indispensable to the implementation of SHP systems. The world is at the dawn of an energy revolution, and the expertise available is a fantastic advantage. The large number of projects in Switzerland that have already been completed or are in progress, particularly in the turbining of drinking water, is a superb portfolio which now needs to be exploited. When exporting is mentioned, there is always talk of the importance of the first market, which is … the domestic market. This is because the large-scale rollout of a technology on the domestic market is the best evidence that can be provided of the effectiveness of that technology. A company that can roll out a product or service on a large scale gains credibility and demonstrates its capacity for such work. The country then becomes one big showcase. In terms of SHP, becoming established in this first market provides an example, and the door then opens onto opportunities in the rest of the world !

This sector is setting an example and shows the path to take in relation to the green economy and the new energy strategy. Sectors such as drinking water treatment, waste water treatment, the smart grid and energy efficiency are following the same path.

Secondly, and in a similar way to other cleantech sectors, the future of the SHP sector is also being shaped by the creation of consortiums. This makes it possible to fulfil the requirements of the export market, via turnkey solutions that are specific to the local context being targeted.

3.3 Existing synergies, a model for exporting

The Swiss SHP sector has already seen a number of synergies become established. Firstly, municipalities work closely with electricity companies to implement and operate SHP plants. Often, when a new SHP plant is to be constructed, a new public limited company is created, in which the municipalities concerned and the electricity companies are shareholders. Secondly, municipalities and electricity companies use external engineering firms when they do not have sufficient engineering expertise and/or resources in-house. This enables these electricity companies to develop SHP plants without having all the expertise themselves.

Project promoters very often use the services of local construction companies to produce the civil engineering components of SHP plants. This enables new synergies to be developed at local/regional level and is a method of operating that is perfectly adapted to export markets.

Cooperating in order to develop certain components

R&D players and engineering firms are also increasingly forming partnerships in order to develop certain components, both in civil engineering (e.g. water intakes and sand traps) and in electromechanical engineering (e.g. new turbines and ICT). With the introduction of the FIT and the interest among large electricity companies in developing SHP, some earlier synergies have turned into competitive situations. Several companies are competing over the same projects and municipalities may change partners[9]. This is revitalising this segment and a competitive situation can certainly result in better solutions for SHP projects. On the other hand, it is likely that the operation of the plants will become concentrated among a small number of players. Thus, fewer and fewer small, private generating companies will be able to produce new SHP plants or renew their water rights concession in Switzerland.

4. What is the potential for small-scale hydropower outside Switzerland ?

As has been shown, the competences to produce SHP plants are widely available in Switzerland, particularly as regards engineering, turbine R&D, and operation. Certain electromechanical components are also developed in the country (including certain types of turbine, such as the Pelton turbine). However, a large number of them are imported.

Within Switzerland, the vast majority of the sites have already been examined. Most of them are already the subject of applications for the FIT and for the right to use the water. Thus, the potential for further development within the domestic market remains limited. Some explanations of this follow.

The large electricity companies come back on the scene

As a result of the promotion of renewable sources of energy, the large electricity companies are once again interested in SHP, and have become major players who have been prospecting on a large scale throughout the country. They are now involved in a significant number of SHP projects. The opportunities for players to gain a position for themselves on new projects remain limited, except perhaps for certain component-manufacturing companies, who will be able to respond to calls for tenders when future SHP plants are constructed.

Moreover, despite the importance of SHP in the energy strategy, its use on a large scale other than in the turbining of drinking water is not clear, because of ecological constraints. This aspect is currently hampering growth in the domestic market, but will very probably prove to be an advantage in foreign markets. We will come back to this later.

In conclusion, as the potential for small-scale hydropower is limited in Switzerland, the sector's expansion will have to take place via the export markets. The next section will give a rapid overview of these markets.

4.1. Overall view

In general, the exploitation of hydropower potential is considerably less-developed in Africa, Asia and parts of South America than in the rest of the world (see figure 3). As far as small-scale hydropower is concerned, there is unfortunately no similar assessment of its potential worldwide. However, according to the report «Renewables 2012 - Global Status Report», the trend for SHP plants is similar in these regions. There are some promising markets for these installations in several countries in Asia, sub-Saharan Africa and Latin America (REN21, 2012). In Europe and North America, the markets are much more saturated and the levels of potential are exploited reasonably well.

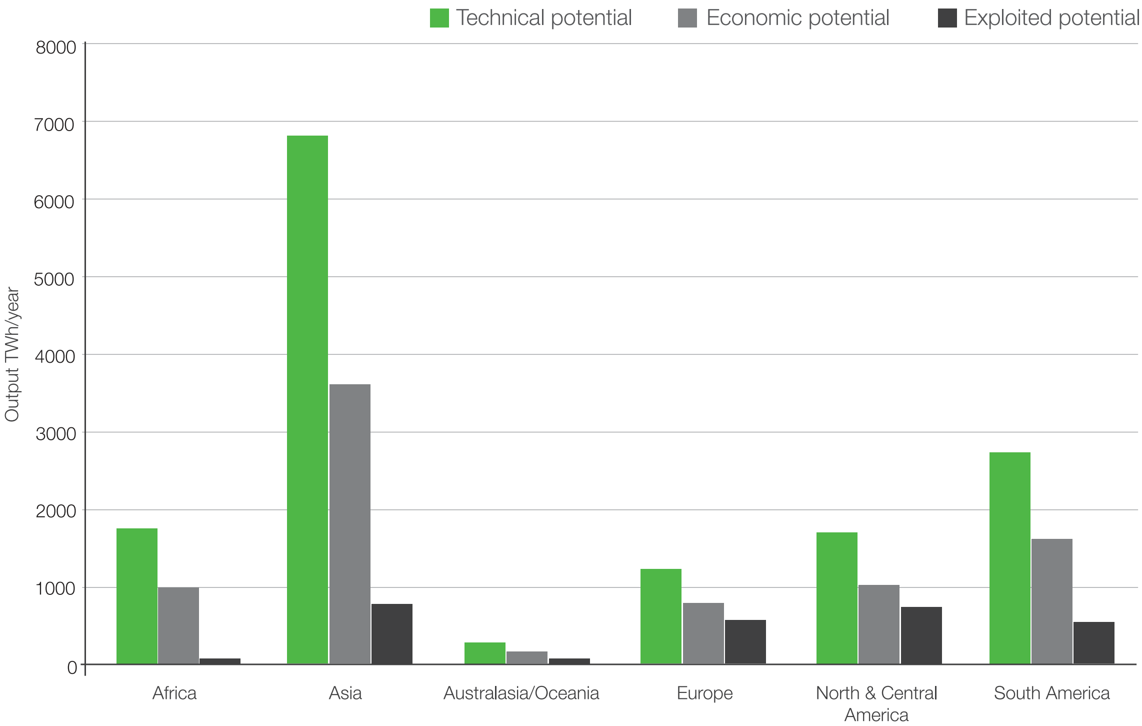


Figure 3: The different levels of hydropower potential worldwide - Source: International Journal of Hydropower and Dams, 2000

The Swiss sector offers a unique degree of expertise

A unique expertise in controlling the entire value chain: this is what Switzerland can offer in the small-scale hydropower sector. With a history and culture shaped by a long experience in exploiting water power, it is capable of playing an important role in the development of small-scale hydropower in emerging countries.

This applies both to individual sectors (in relation to equipment) and overall (with the complete design of an installation). It also includes negotiations with the authorities concerning potential projects or the operation of a plant. The sector's main strengths for the export market are as follows:

- **Engineering know-how**: this expertise continues to be built up by engineering firms, companies involved in component engineering and manufacture, and by certain electricity companies with operations outside Switzerland. This last group has expertise in project management and engineering that is specific to this sector. This expertise covers the whole project, from the start of prospecting to the working design, and includes hydrological, feasibility and environmental studies. It also covers the specific engineering required to produce certain elements such as water intakes, sand traps, penstocks, electromechanical or communications equipment, and data processing and management (ICT).

  This engineering know-how is available, for example, to public authorities that would like to develop SHP plants but do not have the requisite expertise among their own staff (for instance, in countries of the Global South or emerging countries). This work also includes supporting the project, adding to the capacities of the authorities throughout the entire implementation process (identifying potential at various levels, studies, tenders, monitoring the work, management).

  Over the years, the players in Switzerland's SHP sector have also acquired a highly-developed expertise in building relationships between all the parties involved in implementing this type of project (engineering firms, public bodies, municipal operators). This level of experience is essential in ensuring that a project progresses smoothly, and it can readily be exported to help develop local skills in managing and maintaining facilities. It is a skill that complements the technical support and assistance provided, and is covered by the term «project engineering».

- **Electromechanical equipment and information systems**: Going beyond the current modular approach to installations, some types of turbine constructed for Swiss topography are ideally suited to sites outside Switzerland (such an effective head in excess of 200m, a very variable flow rate that ranges from a few hundred litres to over 10,000 litres per second). No additional development work is required, which means implementation can be immediate.

- **Support for the operator**: companies involved in the installation and operation of SHP plants have the ability to «coach» the owners of SHP plants not yet completed. Their long experience in installing and operating such facilities means that the leaders of consortiums are able to establish a system of support. This may include a training course to promote cooperation with the other players (engineering firms, environmental NGOs, large electricity companies), and developing skills in project management and maintenance of the facilities. Where appropriate, twinning relationships can be organised between Swiss municipalities that operate SHP plants and municipalities outside Switzerland that want to develop SHP plants, with a view to sharing experiences and ensuring the long term operation of the installations.

- **Tailored developments**: this means developing solutions that are appropriate to the context within the countries concerned, for instance, for specific conditions of operation. In this case, the objective perspective and experience of the players is a key factor in designing installations that are optimised from an economic and technical point of view.

4. What is the potential for small-scale hydropower outside Switzerland ?

4.2. What potential does the European market offer ?

In 2010, over 21,000 SHP plants were in service in the 27 European Union countries, with a total installed capacity of over 13,000 MW and an annual production of approximately 42 TWh (ESHA, 2011). Six Member States accounted for 85% of the installed capacity, namely Italy (21%), France (17.5%), Spain (15.5%), Germany (14%), Austria (9.4%) and Sweden (7.7%) (Platform «Water Management in the Alps», 2011). Among the new Member States, the largest capacities are to be found in Bulgaria, the Czech Republic, Poland and Romania (ESHA, 2011). Small-scale hydropower is also very important in Norway.

While France and Germany have an exploitable potential of around 1 TWh, which is less than that of Switzerland (which has 1.3 TWh, according to the estimate in the Energy Strategy 2050), Austria's potential amounts to 3 TWh and that of Italy 8.6 TWh.

Taking both renovated and new SHP plants into consideration, the remaining economic potential for small-scale hydropower in the EU-27 is considerable, amounting to 10,000 MW installed capacity and an annual production of 38 TWh (ESHA, 2011). The countries with the greatest potential are Austria, Italy, Poland and Romania.

Taking the environment and legislation into account

However, some caution is necessary. These figures for economic potential do not represent achievable potential, because environmental and institutional dimensions must also be taken into consideration. In some countries with high economic potential, small-scale hydropower faces strong opposition and major institutional barriers. SHP plants may even be excluded from programmes designed to promote renewable sources of energy (SHAPES, MHyLab et al., 2010). In Romania, for instance, a moratorium on new SHP plants was being considered, while in Slovenia, a new regulation on residual flow rates is significantly reducing the financial viability of new SHP plants (ESHA, 2011).

ESHA, the umbrella organisation for small-scale hydropower in Europe, has established a database[10] containing information about present levels of generation, the potential, and the framework conditions in each of the 27 EU Member States, which gives an overview of the sector. The opportunities within the EU for Switzerland's small-scale hydropower sector are therefore limited. Even though there is still some potential to be exploited, the measures for promoting renewable sources of energy within the EU have already attracted a large number of players and revitalised the national SHP sectors.

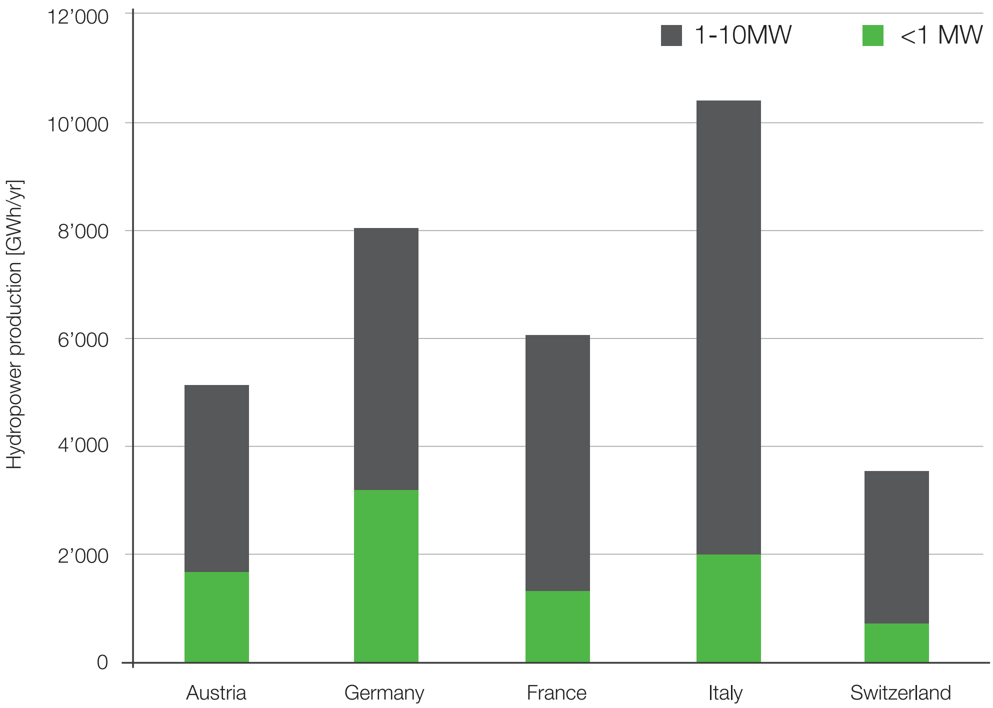
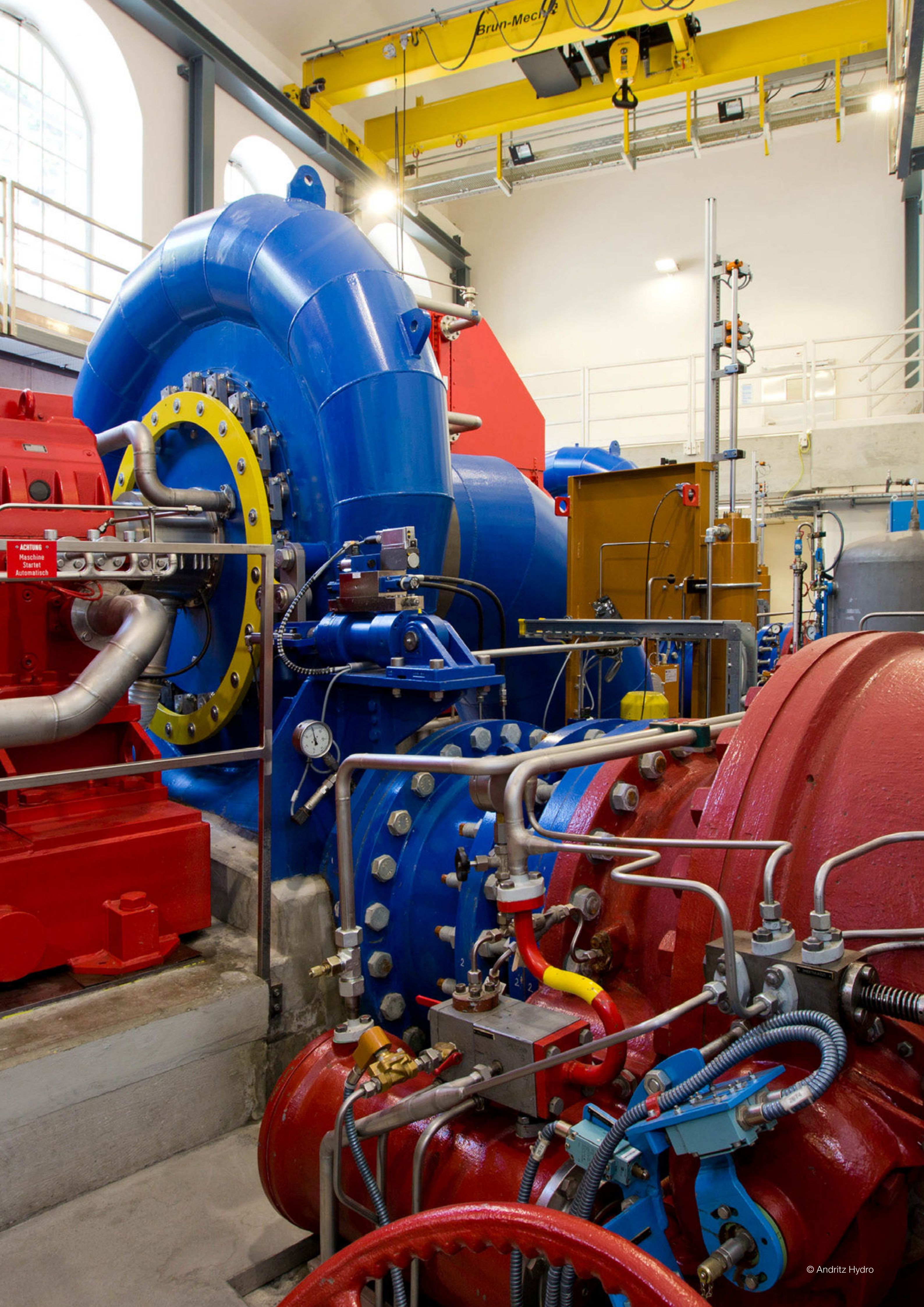


Figure 3: Small-scale hydropower generation in 2009 among Switzerland's neighbours - Sources: (Crettenand, 2012: 86)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4. What is the potential for small-scale hydropower outside Switzerland ?

As the Swiss franc is strong, the services of Swiss engineering firms and the export of electromechanical equipment have generally become less competitive. The countries with remaining potential for SHP plants already have a good deal of experience in operating power plants and so there are few opportunities for coaching or support. In short, except for particular projects requiring expertise in areas in which Swiss players have a great deal more experience than their European competitors (e.g. certain types of turbine, such as Pelton and diagonal turbines, and the turbining of drinking water), the opportunities for the Swiss sector within the EU remain limited.

4.3. Africa, a continent with under-exploited potential

Africa's hydroelectric potential remains less developed than that of other continents (see figure 3), and the same applies to small-scale hydropower. According to Michel de Vivo, only 8% of the hydroelectric potential is currently being exploited[11]. In Cameroon, for example, there is an estimated hydroelectric potential of 20 GW (putting it in second position on the continent after the Democratic Republic of the Congo), of which barely 6% is exploited[12].

With the economic and demographic development that the continent will experience in the next few decades, new infrastructures will be needed to provide access to drinking water, irrigation, and electricity. Multi-purpose facilities enable small-scale hydroelectricity generation to be combined with infrastructures for irrigation and the supply of drinking water, which will reduce investment costs and the effects on the environment that are specific to SHP plants. The Swiss small-scale hydropower sector has expertise in multipurpose facilities that incorporate SHP generation, for example combining SHP with turbining drinking water or waste water, or with irrigation infrastructure.

Access to electricity – a vital development issue

Several of the Millennium Development Goals depend on access to electricity. It is therefore vital to make progress in electrification and that the source of the electricity should be as renewable and sustainable as possible, as well as being adapted to the context of each country. SHP plants fulfil these criteria, and can supply power not only to a national network, but also to local or regional mini-networks. These mini-networks are increasingly important in towns and villages that are sufficiently densely-populated and affluent, where there is a demand for electricity for purposes other than lighting (such as refrigerators and use by SMEs), and where economies of scale make it viable to provide a supply (REN21, 2012).

SHP plants within mini-networks have more chance of being financially viable if they are integrated into a network for supplying players in the local economy (such as mines, industrial SMEs, operators of mobile telephony networks) and public institutions such as health centres. Private individuals can also be supplied provided there are appropriate means of making payment. Here again, it is important to understand the business models for managing an SHP plant within the ecosystem in order to ensure the success and long-term existence of a project.

700 potential sites in Madagascar

The potential for small-scale hydropower in certain countries has been estimated. The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) estimated that Madagascar has over 700 potential sites and that Ethiopia has over 600[13]. There are also a large number of potential sites in Cameroon, Uganda, DR Congo, Rwanda, Tanzania and Mozambique.

While the support policy to be adopted concerning SHP continues to generate fierce debate in the Swiss federal parliament and the various parliaments in Europe, certain projects in Africa can be implemented without subsidies or carbon credits, as Nicolas Crettenand, an expert in small-scale hydropower, explains: « … until 2010, the mini-network in Maroantsetra, a town in north-east Madagascar with 20,000 inhabitants, was supplied with electricity by three diesel generators which regularly broke down or ran out of fuel[14]. A 2.4 MW SHP plant has been built and electricity is now sold at prices slightly lower than those that prevailed before the SHP plant was built. This example shows that there are sites where SHP plants can be built without carbon credits or feed-in tariffs. »

It is also possible for the income from selling electricity locally to be supplemented via carbon credits, such as those developed by the UN within the context of the Clean Development Mechanisms (CDM).

At present, the majority (61%) of these CDM credits for hydroelectric power plants are received by China, and very few projects in Africa (0.9%) receive them (REN21, 2012).

To increase access to these credits in countries of the Global South that are not yet classed as emerging countries, the cost of the procedures for obtaining them must be reduced, for example by standardising these procedures. A model SHP project could be certified in order to receive carbon credits. Access to the credits could then be simplified for any other project of the same type. Some moves towards this have already taken place in relation to the CDM credits (Africa Progress Panel, 2009), but Switzerland could also develop its own carbon credit schemes to compensate for emissions from its planned gas-powered plants.

One approach taken in determining the sites where it would be appropriate to build an SHP plant is to use GIS (Geographic Information Systems) tools to identify villages or small towns that are not connected to the national network and are currently supplied with power by thermal power plants, but are situated near sites with potential for SHP, and in countries where the fuel used in thermal power plants is not subsidised[15].

Switzerland has a good reputation in Africa

The Swiss enjoy a very good reputation in many African countries. The maturity of SHP technologies is perfectly in keeping with the strategies being contemplated in several countries, which want to develop renewable sources of energy in a decentralised manner, and are therefore considering adapting their institutional framework.

4.4. Potential in the rest of the world

The Alliance for Rural Electrification has produced a synthesis of the forecasts for installed SHP power worldwide by 2020. The results are shown in figure 5 and indicate that there will definitely be some development.

In China, the boom in small-scale hydropower (Chinese definition: <25 MW) has continued, with an annual increase in installed capacity ranging from 4 to 6 GW between 2004 and 2008 (Martinot, Sawin et al., 2009). The boom goes on. At the end of 2007, China had built more than 45,000 SHP plants (1900 of which came into service in 2007 alone), for a total installed capacity of 47.4 GW and an annual production of 143 TWh. The potential is estimated to be 128 GW, for an annual production of 350 to 400 TWh[16]. The Chinese market is similar to the European market in that it is already well-developed, so the export opportunities for Swiss companies lie mainly in specialist applications.

In Turkey, annual production by SHP plants in 2002 was 673 GWh, for an installed capacity of 175 MW (Dursun and Gokcol, 2011). Eighty-five per cent of the plants had been built in the last twenty years. Forecasts provide for annual production of 1250 GWh and an installed capacity of 335 MW by 2035. The economic potential has been estimated at 20,000 GWh/year (Dursun and Gokcol, 2011).

Potential to capitalise on Swiss engineering and the export market

Only a small percentage of this potential is therefore exploited. Some valuable opportunities may arise to capitalise on Swiss know-how, whether in engineering, operation, or by exporting electromechanical components. Turkey has invested in large-scale hydropower for a long time and it was only in 2005 that a feed-in tariff was introduced. There are significant administrative barriers related to the processes for obtaining permits and authorisations for renewable energy projects (Murat Sirin and Ege, 2012).

Turkey has a high degree of potential but the exploitation of this potential may be hampered by administrative and circumstantial barriers. Cooperatives and individuals cannot hold permits to generate electricity, so each plant has to be operated by a separate limited company, which is expensive for the local players to set up (Murat Sirin and Ege, 2012). Local opposition to SHP projects is another main barrier (Murat Sirin and Ege, 2012).

Finally, as Turkey is a candidate for membership of the EU, it must also take the Water Framework Directive into consideration, which can hinder the development of small-scale hydropower (Pelikan, 2004).

4. What is the potential for small-scale hydropower outside Switzerland ?

Potential exists in Asia and South America too

More generally, and without going into detail, there is still an attractive level of potential in Asia and South America. In Asia, several countries other than China, such as Sri Lanka, Nepal, Indonesia and Vietnam, are developing small-scale hydropower. The opportunities are there, but the competition is greater than in Africa. In South America, the hydroelectric potential can be exploited to an even greater extent than at present, and there is potential for new SHP plants. Players from western Switzerland, such as DransEnergie (see portrait p. 46), are already involved in Peru, for example. Others may follow.

In developing countries, the barriers to the development of hydropower are mainly of a financial nature. Firstly, where there are no adequate feed-in tariffs, the rates at which the electricity is bought do not cover costs and, secondly, it is difficult to find the necessary funds to invest in these SHP projects, which have a longer ROI time than other technologies (such as gas-powered generating plants). Finally, in some countries, it is difficult for private players to inject current into the national network.

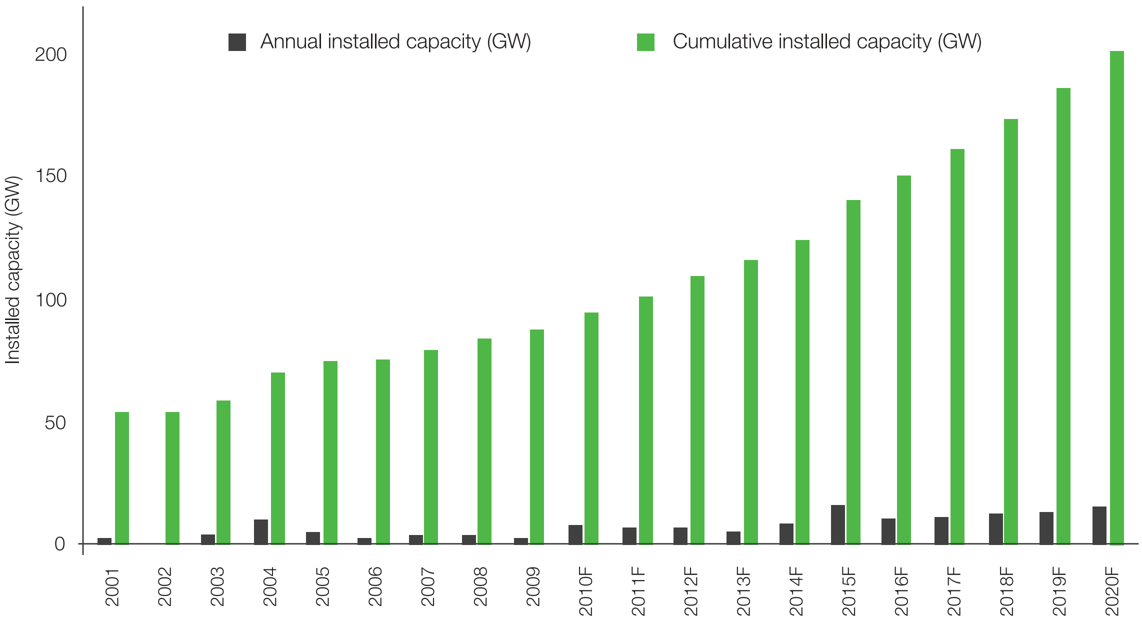

Figure 5: Worldwide installed capacity in GW for small-scale hydropower from 2001 to 2020 - Source: (Rolland, 2011)

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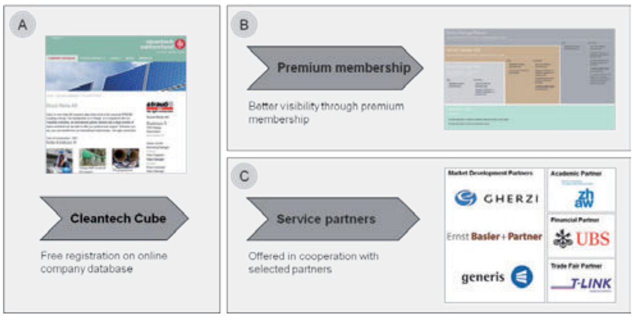

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5. Summary and conclusion

The value chain for the small-scale hydropower sector in Switzerland is well-developed, with a particular emphasis on research and development, engineering and operation. There are specific structures for R&D, which include, among others, the Energypolis platform that is being created in Valais. Several players produce components and installations. The development of new components, particularly electromechanical components such as turbines, offers potential for optimisation.

In terms of energy…

In Switzerland, the electricity generated by small-scale hydropower could increase by around 50% by 2050. This will require, firstly, an improvement in the institutional framework conditions, and secondly, finding an acceptable balance between electricity generation and environmental protection. The potential for developing new SHP plants nevertheless remains limited. Other opportunities, such as geothermal, solar photovoltaic or wind power need to be explored, in order to ensure the country's electricity supply in the long term.

In economic terms…

Within the EU, there is still scope to develop small-scale hydropower. The remaining economic potential amounts to almost 100% of the electricity generated in 2010. Taking account of the environmental and social dimensions, only part of this economic potential will be exploited. The European small-scale hydropower sector is already well-established, so the opportunities for Swiss players remain limited to SHP projects that require specific know-how and a high degree of expertise (e.g. certain types of turbines, integration of SHP into infrastructures, integration into the environment).

Africa offers some significant opportunities. This continent, which will experience major economic development, will also need a supply of electricity in rural areas and in small urban communities that are not yet connected to the national electricity network. The experience and know-how of players from the Swiss SHP sector who are already involved in Africa offer some very attractive solutions for these countries.

Standardised SHP plants specifically developed for sites with a high hydropower potential and where the technical yield is not the prime concern offer the optimum solution. Swiss expertise in multipurpose projects adds yet more to this export offer, enabling electrical, drinking water and irrigation infrastructures to be developed together.

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6. Overview of the main players in Switzerland

Civil engineering — Impact and environment — School/Research

Electromechanical engineering — Other

1.	ABB Hochspannungstechnik	Zürich, ZH	Electromechanical engineering
2.	AF-Consult	Baden, AG	Civil engineering
3.	Alpiq	Olten, SO et Lausanne, VD	Other
4.	Andritz Hydro AG	Kriens, LU et Vevey, VD	Civil engineering, Electromechanical engineering
5.	Aquavision Engineering	Ecublens, VD	Other
6.	Axpo Holding	Baden, AG	Other
7.	Basler & Hofmann	Esslingen, ZH	Civil engineering, Electromechanical engineering
8.	BG Ingénieurs Conseil	Lausanne, VD	Civil engineering, Electromechanical engineering
9.	Blue-Water-Power	Schafisheim, AG	Electromechanical engineering
10.	Bureau d'études biologiques R. Delarze	Aigle, VD	Impact and environment
11.	CERT ingénierie	Martigny, VS	Civil engineering
12.	Cla-Val	Romanel-sur-Lausanne, VD	Electromechanical engineering
13.	Cordonier & Rey	Sierre, VS	Civil engineering
14.	Castronic	Bussigny-sur-Lausanne, VD	Electromechanical engineering
15.	CRSM	Yverdon-les-Bains, VD	Electromechanical engineering
16.	CSD Ingénieurs conseils	Lausanne, VD	Civil engineering, Electromechanical engineering
17.	DPE Electrotechnique	Sierre, VS	Electromechanical engineering
18.	DransEnergie	Orsières, VS	Electromechanical engineering, Civil engineering, Other
19.	Drosera	Sion, VS	Impact and environment
20.	e-dric	Mont-sur-Lausanne, VD	Impact and environment, Other
21.	Entegra Wasserkraft	St-Gall, SG and Coire, GR	Civil engineering, Electromechanical engineering
22.	EPFL	Lausanne, VD	School/Research
23.	Esotec	Innertkirchen, BE	Civil engineering, Electromechanical engineering

24. FMV ... Sion, VS
25. Gasa Hydro ... St-Légier, VD
26. Gebrüder Meier ... Regensdorf, ZH
27. Genossenschaft Wasserwirbelkraftwerke ... Schöftland, AG
28. GREN ... Genève, GE
29. Greenwatt ... Granges-Paccot, FR
30. Häny ... Jona, SG
31. HEIG-VD ... Yverdon-les-Bains, VD
32. HES-SO Valais Wallis ... Sion, VS
33. Hochschule Technik + Architektur Luzern ... Horw, LU
34. Hydro Exploitation ... Sion, VS
35. Hydro-Solar Engineering ... Niederdorf, BL
36. Hydrocosmos ... Billens, FR
37. Hydroelectra ... Heerbrugg, SG
38. Kissling + Zbinden ... Spiez, BE
39. Idealp ... Sion, VS
40. IM Maggia Engineering ... Locarno, TI
41. Ingenieurbüro P. Kast ... Münchenbuchsee, BE
42. Interplan Energietechnik ... Laupen, BE
43. Iteco ... Affoltern a Albis, ZH
44. IUB Engineering ... Berne, BE
45. Jacquier-Luisier ... Evionnaz, VS
46. JMC Engineering ... Baulmes, VD
47. Kobel Elektrotechnik ... Affoltern i. E., BE
48. Kurmann & Cretton ... Monthey, VS
49. Louis-Philippe Nicollier ... Yvorne, VD
50. Mhylab ... Montcherand, VD
51. Ofatec ... La Conversion, VD
52. Optydro ... Sion, VS
53. Planair ... La Sagne, NE
54. Pra Ing. Conseils ... Sion, VS
55. Premel ... Preonzo, IT
56. Program ... Prangins, VD
57. Repower ... Poschiavo, GR
58. Revita ... Holderbank, AG
59. Rittmeyer ... Baar, ZG
60. Romande Energie ... Morges, VD
61. RWB Holding ... Porrentruy, JU
62. Ryser Ingenieure ... Berne, BE
63. SBP Ingenieure ... Rarogne, VS
64. SD Ingenierie ... Lausanne, VD
65. Sol-E (BKW) ... Berne, BE
66. Stahleinbau ... Stalden, VS
67. Stucky ... Renens, VD
68. Sulzer ... Winterthur, ZH
69. Telsa ... Sion, VS
70. Valélectric Farner ... St-Pierre-de-Clages, VS
71. Vogel Pompes ... Cornaux, NE
72. Zobo Hydropower ... Brienz, BE
73. University of Berne ... Berne, BE
74. Entec ... Saint-Gall, SG
75. Maurer Elektromaschinen ... Schöftland, AG
76. Sigrist ... Sachseln, OW
77. Eco Power Systems ... Cham, ZG
78. Urs Baumann ... Samstagern, ZH
79. EPFZ ... Zurich, ZH
80. EAWAG ... Dübendorf, ZH
81. Müller Turbinen ... Unterlunkhofen, AG
82. EnergyOn ... Viège, VS
83. Misurio ... Viège, VS
84. SKAT ... Lausanne, VD et St-Gall, SG
85. Power Vision Engineering ... Ecublens, VD

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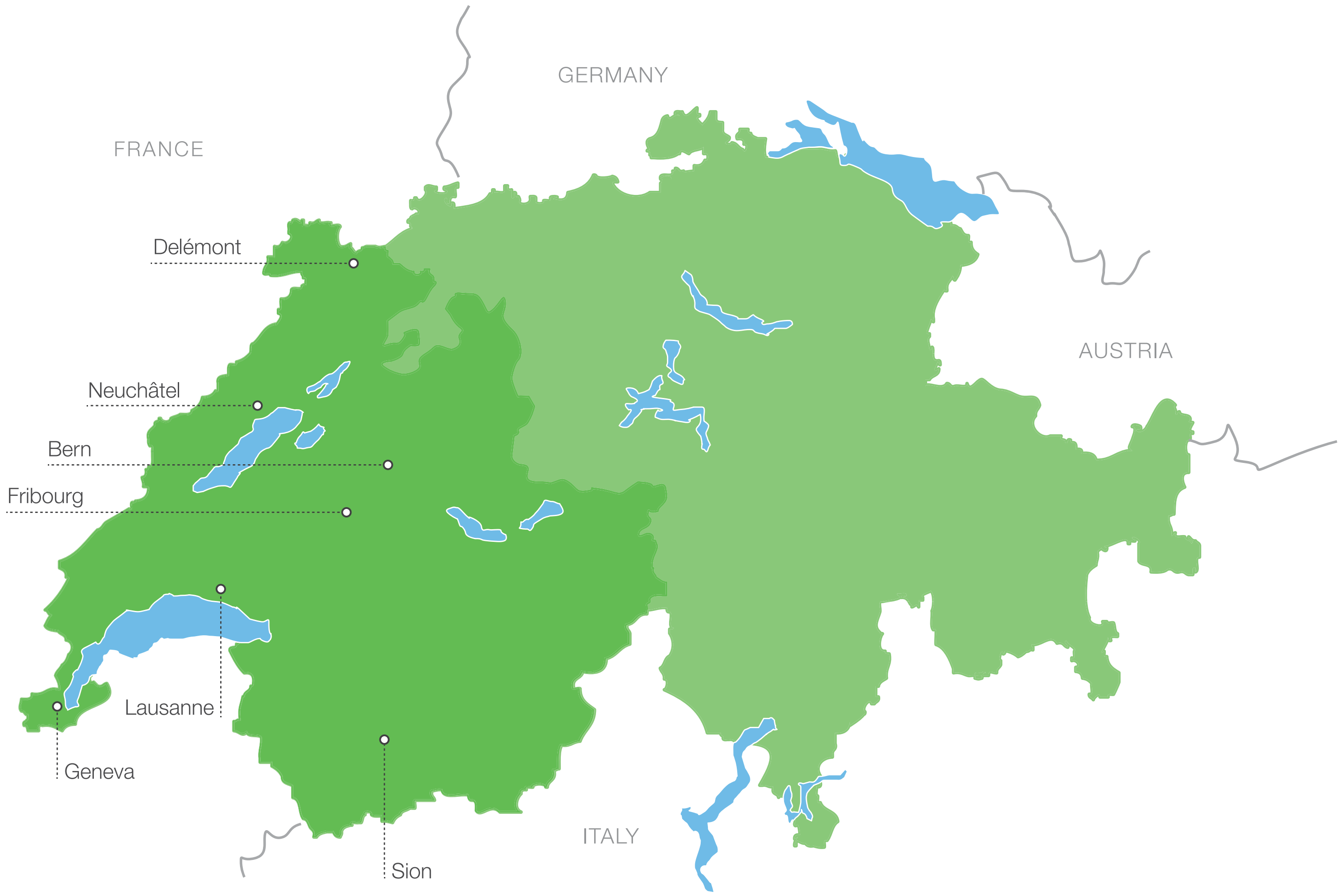

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14 portraits

ANDRITZ Hydro SA – small-scale systems from a giant of the water industry

Involved in hydropower for over 170 years, ANDRITZ Hydro is one of the world's leading suppliers of systems and electromechanical services for hydroelectric plants. It also develops solutions for low-power installations.

ANDRITZ Hydro and hydroelectricity go back a long way together. Originally founded as Bell Escher Wyss, the company has been supplying and servicing hydraulic turbines for electricity generation since 1894. Building on its experience and the activities of its research and development department, ANDRITZ Hydro has developed a modular concept for equipment intended for low-power hydroelectric plants. Named Compact Hydro, this concept provides turnkey solutions that encompass both products and services. « In Switzerland, the small-scale hydropower market represents 44% of our hydroelectricity business », says Ralph Zwingli, market manager for Switzerland within the Compact Hydro Division. It mainly concerns installations with an output ranging from 5 MW to a maximum of 30MW. « With the acquisition last year of a company specialising in mini-hydropower, we are also developing very low power systems, starting at 20kW. » The Compact Hydro « Water to wire » concept includes the entire electromechanical installation, in other words the turbine, speed-increasing gearbox, generator, guard valve, and the measurement, protection and control systems, as well as all the electrical and mechanical equipment necessary to the operation of the plant.

Involved at every stage of a project

The Compact Hydro concept is used by the specialists at ANDRITZ Hydro to assist a diverse group of clients. « We work just as well with individuals as with public bodies or energy suppliers. » The company is able to advise them from the feasibility study stage of a project onwards; it can also provide the project monitoring, engineering, design and manufacturing required. « We manufacture the critical hydraulic components, such as wheels and distributors, ourselves. Other components are made by subcontractors in Switzerland and the rest of Europe. As regards the electrical part, we manufacture generators producing 25MW upwards. » Installation, commissioning, and operator training are also included. In addition, ANDRITZ Hydro and its partners maintain installations and perform routine servicing, repair work, and troubleshooting in the event of any unexpected malfunction. The customer service department is available 24/7, and the geographic distribution of the company's four Swiss sites (Vevey, Zurich, Kriens and Jonschwil) means that in an emergency, its staff can be at a client's site within a few hours.

Research and development also has an important position within ANDRITZ Hydro's activities. « Although this mainly concerns large-scale hydropower, the smaller installations also benefit from the advances that it makes. » The R&D includes flow modelling to improve the performance of installations, testing component robustness, and producing innovations in electrical technology. A global approach means that the company can provide complete, optimum solutions.

« We produce between 20 and 30 machines per year in Switzerland, for about fifteen projects. We replace existing systems as well as commissioning new installations. » One of the latest projects is in progress at Loèche-les-Bains, in Haut-Valais, for the company ReLL Energie. « We've overhauled the existing power plant. Now we're going to install a second turbine, in this instance a 7MW horizontal Pelton turbine. »

ANDRITZ Hydro SA
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520 in Switzerland, 60 of whom work within
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CSD Engineers, customised support for mini-hydropower projects

Formed over forty years ago, the CSD group has 18 subsidiaries in Switzerland and a presence in four other European countries. This geographic coverage, combined with the multidisciplinary skills of its staff, means that it can deal with all aspects of its clients' projects, which include mini-hydropower installations.

The CSD group divides its services into three fields of activity : environment and geology, buildings and infrastructure, and energy and water. « This multidisciplinary aspect is a major advantage for us, because it enables us to offer a total service and manage projects from A to Z », says Stéphane Maret, a member of the management board and the director of the Energy and Water field. « Via a single partner, our clients benefit from the expertise of three engineering offices. » Along with wind, biomass, geothermal and solar power, mini-hydropower is an important activity for the group within the renewable energy field. « We think that mini-hydropower still has a lot of potential for development. Indeed, it has its place within Switzerland's Energy Strategy 2050, and the country still has plenty of sites that are suitable for this type of installation. »

Civil engineers, environment specialists, geologists, hydrogeologists, geographers, geotechnical engineers, chemists, biologists, foresters, process engineers or energy engineers – there is a wealth of expertise within the group. What's more, CSD has a network of 30 subsidiaries, 18 of which are in Switzerland, the others being in Belgium, Germany, Italy and Lithuania. « Having a local presence is part of our strategy. This proximity means that our clients have local access to all the expertise within the group, because our subsidiaries operate as a network. »

Anticipated environmental impact

« As an engineering firm, we're able to manage a mini-hydropower project in its entirety, producing a turnkey installation that's customised. However, depending on what's required, we can also restrict our involvement to a specific aspect of the design, installation or technical features of a mini-hydropower plant. » The expertise of CSD's specialists enables the group to provide all the services related to abstraction and turbining, whether this involves site research, technical, economic and profitability analyses, looking for subsidies, detailed planning, tender analysis, or monitoring work at the site until final completion. « We can also take care of the hydrology and civil engineering parts of an installation, as well as the environmental aspects, such as impact reports or specialist reports on the plants and wildlife, the effect on surface and underground water, etc. »

Within the field of mini-hydropower, CSD's clients are mainly municipalities and other public authorities, as well as electricity distribution companies. « We've already successfully completed numerous projects. » The group recently carried out all the engineering work for a turbining project for the Gordola municipality, in the Ticino canton. « It involved a plant with a capacity of 30 kW, where a new Pelton turbine and a new surge tank had been installed within the existing drinking-water network. We carried out the entire project and managed the work at the site. » The company also performed part of the work for the mini-hydropower plant in the Arbaz municipality, in the Valais canton. « We were responsible for carrying out the feasibility study for the layout, comparing the costs of the variant designs, putting together the documents required by the planning process, and the associated procedures, as well as project-managing the work at the site. »

CSD Group

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DPE Electrotechnique SA – automation engineering

Specialising in electronic engineering, DPE Electrotechnique SA has been developing its activities in the field of mini hydropower for several years. Skilled in the electronic aspects of turbine installations, it is responsible for their automation via the design and implementation of the control systems.

Created in 1992 and based in Sierre, the company now has some fifteen employees, including nine engineers who specialise in electrical engineering and industrial automation. DPE Electrotechnique SA uses its expertise for the planning of electrical installations as well as in automation and industrial engineering. Working in numerous sectors, the company benefits in particular from in-depth experience in projects concerned with water management – drinking water, waste water, turbines, monitoring and various other measures. It is particularly active in the automation and remote management of drinking water networks, pumping stations and drinking water treatment plants; its know-how is also brought to bear in waste water treatment projects.

« For the last 2-3 years we have also been very active in the mini hydropower market, » says Pierre-Alain Gabbud, the company's director. « This is an additional element that allows for the global integration of water management systems. » Its engineers design the automation of turbine installations, with the majority of projects being delivered as turnkey operations. The company is also involved in the renovation of existing control systems.

From microturbines to large-scale installations

The control system is a key element in hydroelectric mini-power plants, which are usually operated automatically, without supervision, thereby significantly reducing production costs by limiting the need for human intervention. The automated systems developed by DPE comprise in particular the provision of an alternator, a control panel and active and passive safety devices upstream of the turbine, including the differential protection of the penstock.

The company also undertakes the automation of water intakes, sand and grit chambers, etc. In practice, the expertise of DPE extends from electrical engineering for specific projects to the design of control panels (the manufacture of which is subcontracted to a specialist company), and the installation, commissioning and aftersales support. « We operate as a general-purpose company, with responsibility for the electrical aspects of the project right through to completion. »

Mini hydropower activities currently account for just over 20% of the company's turnover. « And this share is growing. » More specifically, DPE has already handled over 10 turbine installations, either integrating them into drinking water supply systems, or supplying complete control systems. « We work in particular with the company Gasa-Hydro SA, for whom we automate all the machinery. Most recently we were involved in the installation of the Rivaz small-scale hydroelectric plant, which went live in February. »

DPE also deals with micro-turbines with less than 1kW output. « These installations are designed to safeguard the electrical requirements of the process in zones that are not served by the industrial supplies. » At the other end of the scale, the company is currently undertaking studies for the Alpine Aqueduct project in Crans-Montana. « We have also evaluated inverse pumping solutions, but have not yet had the chance to deploy them. Technological developments will no doubt enable us to do so in the near future. »

DPE Electrotechnique SA

1992

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DransEnergie SA – combining forces in the Entremont valley

A new name in the electricity generation and distribution sector, DransEnergie SA has taken over the activities of another company, Forces Motrices d'Orsières. It uses its expertise in the renewable energy field, specialising in mini-hydropower.

The company was formally created in December 2013. At the instigation of Forces Motrices d'Orsières (FMO), the Valaisan municipalities of Bourg-Saint-Pierre, Liddes and Orsières, plus the companies Forces Motrices du Grand-Saint-Bernard (FGB) and Forces Motrices de Sembrancher (FMS), worked together to create an entity shared by the regional players in electricity generation and distribution. By pooling their resources, the founding shareholders of DransEnergie SA aim to benefit from the resultant synergy, strengthen their expertise and develop regional activities.

« The activities of Forces Motrices d'Orsières within the water sector had developed considerably », is the summary given by Michel Rausis, the managing director of DransEnergie SA. « It made sense to create a new structure that was devoted more specifically to hydropower. We manage large-scale hydropower schemes, as well as being involved in mini-hydropower projects. » Michel Rausis, who has headed FMO for around twenty years, adds that the transition to this new structure took place without a hitch. And so, bolstered by its experience with around fifteen mini-hydropower projects that were successfully implemented under the aegis of FMO, DransEnergie SA started operations in January 2014. « Two new projects are currently awaiting authorisation and we have about ten more in the pipeline. »

Turnkey installations

The company's services cover every aspect of implementing a mini-turbining project. Whether this involves the preliminary design stage, compiling the technical file and authorisation documents, producing the specifications for the various items of service provision, analysing tenders, or actually producing the installation, the company's staff – all appointed by FMO – are able to offer turnkey solutions. « We have in-house skills in civil, mechanical and electrical engineering, and in operations management, which enable us to see the different stages of a project through to a successful conclusion. We can also manufacture electromechanical components, including control systems and electrical cabinets; only the turbines and water pipes are produced by an external supplier. » The staff are experienced in maintaining and operating hydroelectric installations, which means that they also have an in-depth knowledge of the technical features of this type of installation. DransEnergie SA is therefore fully capable of performing servicing and preventive maintenance work on mini-hydropower plants.

The company's 47 employees, plus 4 apprentices and 3 trainees, are also involved in managing the technical infrastructures (electricity networks, generating plants and dams) that belong to its shareholders, who are electricity producers and distributors. DransEnergie SA is also able to offer its many services to third parties. These include inspecting electrical installations, producing switchgears for the industry, studies concerning water and new sources of renewable energy, as well as all the safety, administrative, financial and communication aspects related to these services.

DransEnergie SA

2013

54

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Predictive modelling and e-dric.ch

Founded eight years ago by two engineers fascinated by water, this company has already established a solid reputation for itself in hydraulic engineering and hydrological forecasting. It makes this expertise available for projects that include mini-hydropower facilities.

« Modelling is the common denominator of our activities. » This is the summary given by Frédéric Jordan, who co-founded e-dric.ch in 2006 with Philippe Heller. After gaining their doctorates, these two young civil engineers decided to pool the skills they had acquired at EPFL's Hydraulic Constructions Laboratory, and the company's current employees are all engineers from EPFL or an equivalent institution. « About half of them have degrees in environmental sciences and water management, a quarter have degrees in telecommunications and software development, a quarter are civil engineers and one person is a mechanical engineer. » Using modelling software that they developed themselves, they offer their clients practical solutions in different fields related to water management. And although, as far as hydroelectricity is concerned, the company is more involved with large installations, it nevertheless achieves 10% of its turnover from mini-hydropower projects.

Economic optimisation

« Putting it simply, operational hydrological forecasting enables you to know what the flow rate will be in a river, whereas hydraulic modelling provides information about features such as speed, height and pressure. » Will a watercourse flow as you expect? Will an installation behave as you want it to? This is the kind of essential information that enables the dimensions and future output of a planned installation to be calculated as accurately as possible. « Hydrological modelling saves a lot of time when a project is being developed, because it reduces the average time during which readings are taken at measuring stations installed along a watercourse during the preliminary design phase. What's more, these stations have a margin of error of between 10 and 30%, so when they're used on their own, they're only moderately reliable. » By modelling, the forecasts can thus be refined and bring the measurement-taking period down from two years to about six months. « A model makes best use of a measurement, it doesn't replace it. »

However, Frédéric Jordan emphasises that, in many cases, projects for mini hydropower plants rely only on theoretical estimates, which are used as the basis for producing water flow statistics. « Sometimes, work is started at sites on the basis of hydrological surveys carried out in one hour! If you get it wrong, the probability of failure is high: you risk constructing an installation that is too small or too large, or even - mistakenly - not constructing an installation at all. » Such errors can severely affect a project's financial viability.

It is with economic optimisation specifically in mind that some of e-dric.ch's clients (mainly electricity generating companies or engineering firms) also ask its experts for a preliminary design for the installation. Penstock diameter, wheel type, water intake, the shape of the sand traps or the surge tank, everything is examined closely to optimise generation, yield, and therefore the anticipated profit. « To date, we've designed about ten installations and carried out more than 20 modelling operations. » This mainly concerns high-head mini-hydropower plants with a penstock; 20% of the company's work also concerns run-of-river installations and a small proportion involves drinking-water pipes.

e-dric.ch

2006

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Gasa SA, a passionate advocate of hydropower

Based in Vaud, this company has installed some fifty small hydroelectric plants since 1989. Its director is calling for a relaxation of the regulations and an energy policy that favours installations of less than 300 kW equivalent output as defined in Swiss legislation.

Hydropower has shaped the history of family business Gasa SA. Now directed by Pierre-Alain Galé, the company originated from the vision of his father Roger Galé with the participation of his brother Jean-Claude. A civil engineer and business graduate, Pierre-Alain Galé left his post as director of the company Bertholet+Mathis SA two years ago to devote his energies to small-scale hydropower. « We specialise in the design, construction, turnkey sales and maintenance of small-scale hydroelectric plants. » These are installations of between 35 and 2,300 kW output, more than 70% of which have an equivalent output of less than 300 kW. « We also act as an energy supplier, thanks to the plants we have constructed which we own or co-own. » The vast majority of their systems have been installed in Valais and the canton of Vaud. They make use of the water from high heads of between 80 and 875 m, mainly in the municipal drinking water networks. « These offer the benefit of having a low or even non-existent impact on the environment. This is at the heart of our activities, although we have also installed plants in waste water flows upstream or downstream of a WWTP and in run-of-the-river situations. »

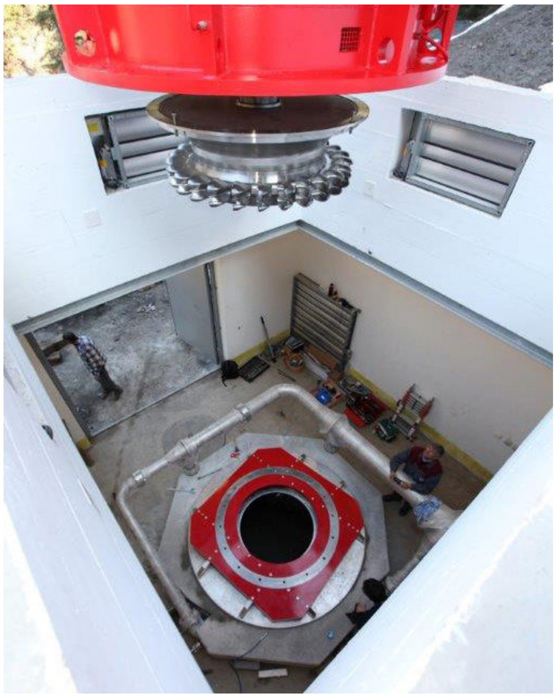
Safeguarding the sector

Gasa SA links up with various regional enterprises to benefit from their expertise. Firstly, there is the mechanical workshop of Nicollier, in Yvorne, which manufactures the Pelton turbines at the heart of the facilities. The control systems are produced by the Sierre engineering company DPE Electrotechnique SA, while the penstocks are often commissioned from Charly Gaillard & Fils in Conthey. Where Gasa SA is responsible for the civil engineering works, it subcontracts them to local companies as a matter of course. This is a complete skills chain which enables the company to offer turnkey installations with a full range of services including the hydraulic, electrical and in some cases civil engineering aspects.

« We often respond to calls for tender once our clients have obtained the necessary consents for the construction and exploitation of their projects. In some cases we can also help with these procedures. We are also able to offer our services in relation to certain specific aspects of a project, as required. » One of the company's most recent completed projects is their involvement in the construction of the Rivaz plant on behalf of renewable energy company Romande Energie Renouvelable.

« We successfully tendered for the turbine-alternator component with its control system, and for the management of the regulation. » Pierre-Alain Galé's attention is currently focused on an installation under construction at Vionnaz. Gasa SA has also successfully tendered for a project for Sierre-Energie in the municipality of Muraz (canton of Valais). Other projects, such as the one at Brent, above Montreux, are under discussion.

A passionate advocate of mini hydropower, Pierre-Alain Galé is concerned about the future of the sector, considering the position of the Federal Council with regard to installations of less than 300 kW equivalent output. « These small plants are extremely important for the diversification of energy supplies. 300 kWh produced over a year equates to the consumption of around 650 households. Multiply this by the potential number of installations possible in Switzerland and this figure, while not huge, is certainly of interest! » He also stresses in particular their low price and the significant proportion of winter electricity output by some installations. « Therefore they should be increasing the incentives to establish these small-scale plants, not scrapping them! »



Gasa-Hydro SA

2012 (Gasa SA was founded in 1989)

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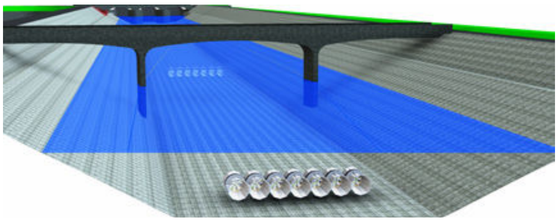
Researchers at the HES-SO Valais-Wallis are designing tomorrow's mini-hydropower systems

The School of Engineering at the HES-SO Valais-Wallis has been working in the field of hydroelectricity for over fifteen years. Its research focuses in particular on development, advice and consultancy related to hydroelectric infrastructures, including low-power installations.

The Institute of Systems Engineering at the HES-SO Valais-Wallis has around fifteen researchers involved in work on hydroelectricity. « We're using numerical flow simulations to predict the performance and behaviour of a hydropower turbine and we're also doing experimental work, using test benches, to develop new technologies », says Cécile Münch-Alligné, professor of hydropower engineering. Several innovative projects have already emerged from this work, including the installation of a 50 kW variable-speed reverse pump in the drinking-water network in the town of Sion, some ten years or so ago.

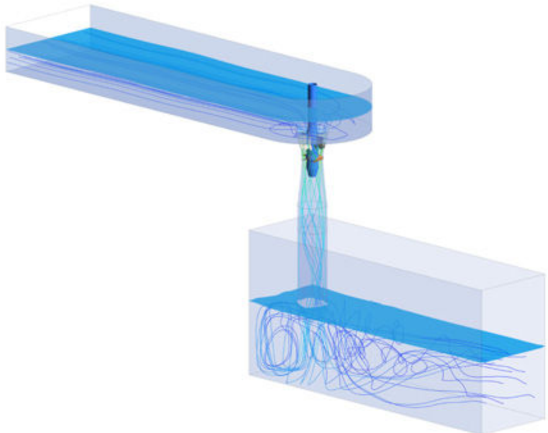


« It was a first for this type of equipment. » Similarly, researchers from the HES-SO Valais-Wallis have carried out several preliminary studies on the potential for small-scale hydropower in the canton, as part of the BlueArk programme. « We've identified 50 possibilities for projects, and this work has also spurred the municipalities into becoming involved in hydropower generation. There's lots of potential in Valais. »

Cantonal and federal funding

In fact, the studies currently being undertaken by Cécile Münch-Alligné and her team are being funded by the Valais canton, as part of The Ark Energy programme. To begin with, there's the Hydro VS project, conducted in conjunction with EPFL and consisting of several parts. The first of these is the development of a micro-turbine with two counter-rotating wheels. It is intended for mini-hydropower plants within the drinking-water network, and should enable plants with a very low power output (less than 100 kW) to be installed. « We're developing this project from beginning to end, in conjunction with EPFL. » Another area of research within Hydro VS is the design of a hydrokinetic turbine for the tailrace and headrace tunnels of existing power plants. « This technology will make it possible to harness the kinetic energy of the water.

An initial prototype is being developed with a view to installation at the pilot site at Lavey, which belongs to the water and energy supply company Services industriels de Lausanne. » This is therefore applied research, whose eventual objective is to produce marketable products and manufacture them on a large scale. In order to do this, the Hydro VS project has also been incorporated into the national Swiss Competence Centers for Energy Research (SCCER) programme, financed by the Commission for Technology and Innovation (CTI). « This extra federal funding will help to advance the development of our project. »



Other studies are also in progress. « We're investigating the value of installing micro pumped-storage power plants to balance the electricity network, which can sometimes be destabilised by the injections of current from an increasing number of solar panels. » Two small lakes in the Arbaz municipality have been selected for this purpose. The aim of this project, conducted by the HES-SO Valais-Wallis in conjunction with EPFL, the CREM and CimArk, is to identify the site's hydropower potential and the effect that a micro pumped-storage power plant might have on the municipality's network. Finally, mention should be made of the research being conducted at a pilot installation in the drinking-water network at Savièse. « We've equipped the site with instruments in order to collect some statistics and we'll soon be installing different machines there and observing how each one behaves under real-life conditions. »

HES-SO Valais-Wallis, Institute of Systems Engineering

1988

about fifteen researchers working on hydropower

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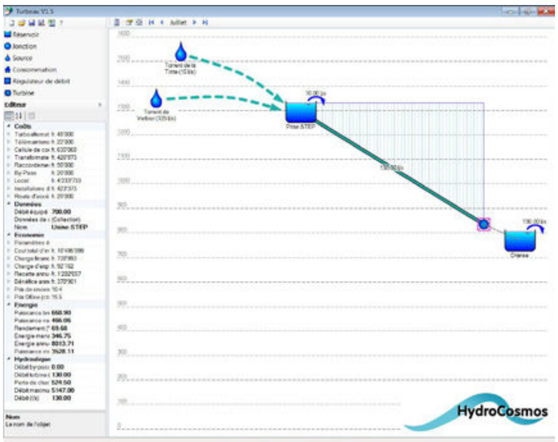
HydroCosmos SA meets the challenges of water management

This Valais-based company offers numerical modelling in every field related to hydraulic engineering. This specialism means that it participates in projects to construct or renovate hydropower plants, including low-power plants.

Whether it involves mapping hydrological risks, optimising the design of watercourses or hydroelectric installations, or managing the supply and outflow of water, the engineers at HydroCosmos SA are able to meet their clients' water requirements whilst also limiting any adverse effects. « In our work, we mainly use software that we've developed ourselves. We do use modelling programmes that are available on the market, but to a lesser extent », says Niki Beyer, a civil engineer from EPF who co-founded HydroCosmos SA with Jérôme Dubois. The company is cooperating with CREALP, a Sion-based centre for research into the Alpine environment, in order to keep innovating and meet its clients' requirements as closely as possible, in sectors that are continually changing. « We're working together to develop a new prediction and optimisation software solution for hydraulic installations. » One of the potential uses of this software lies in the management of hydroelectric plants, to predict the water flow rate so that turbining can be made profitable. Optimisation of hydraulic installations forms part of the company's area of expertise.



Assessing the potential of drinking-water pipes

Whatever the size of the turbining installation concerned, the engineers at HydroCosmos SA have the requisite skills to support this optimisation work by providing additional services during the preparatory phase of a project. These services include data acquisition and validation, design and dimensioning of structures, numerical simulation and optimisation, as well as analysing and making use of the results. Modelling can be applied both to the construction of new plants and to the optimisation of existing installations.

« Our most recent project was oriented more towards construction and involved work on the hydroelectric plant at Bramois, which was originally commissioned in 1915. We were appointed by Hydro Exploitation SA to use 2D modelling to optimise the tailrace of this old installation. »

Small hydropower plants currently represent only a small proportion of the installations examined by Niki Beyer and the HydroCosmos team. « The electricity produced by mini-hydropower is still quite expensive, but things may change if there is the political will to promote this type of development. » Jérôme Dubois, the co-founder of HydroCosmos SA, showed an interest in this sector as long as ten years ago, when, in partnership with EPFL's Hydraulic Constructions Laboratory, he developed a software package that was specifically designed to assess the profitability of a mini-hydropower installation. « This tool was intended for municipalities, so that they could assess the potential of their drinking-water pipes for generating hydroelectricity. » Several Swiss local authorities have used this software, including Bagnes, which is interested in « green » electricity. « By using computer modelling, the initiators of a small hydropower project can find out information such as the flow rate to be turbined and the height of fall at which this turbining will be most efficient. This information will enable them to calculate the cost of the installation and confirm its future profitability, before they embark on any construction work. »

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Jacquier-Luisier uses water to produce the energy of today

Founded in 1989, this mechanical engineering workshop, based in Evionnaz, specialises in the manufacture of Pelton turbines, a technology that is especially well-suited to mini hydropower installations with medium and high heads. It offers its clients turnkey and made-to-measure solutions.

« We make all the parts without subcontracting, in our 1,700 m2 workshop, using around sixty conventional and digital machines, » begins Claude Luisier, the founder, together with Claude Jacquier, of the company Jacquier-Luisier SA. Alongside its machinery construction, digital control components and gear cutting activities, the company also specialises in the manufacture of Pelton turbines, used in small-scale hydropower installations. At the heart of a Pelton turbine is a bucket wheel, which is driven by the kinetic energy of water introduced by one or more adjustable injectors. This particularly efficient wheel enables an energy yield of around 90% to be achieved. « The water arrives under high pressure, and great precision in the design of the buckets enables the losses to be kept to a minimum. By way of comparison, a heat engine coupled to an alternator will never give such a high yield ; the expected output is generally around 65%. »

Working on the basis of two or three installations per annum, the implementation of mini hydroelectric plant projects represents 25% of the workshop's activities. « There is huge potential in Valais for small-scale hydropower with medium and high heads. »

Indeed, in most of the canton's municipalities, springs and reservoirs are located at altitudes of 1,500 to 2,000 metres. « Traditionally, where there is a penstock leading to a village, a sluice gate enables the pressure to be reduced prior to distribution. All that is needed to produce energy, therefore, is to redirect this water via a bypass and turbine. This has no impact on the environment nor effect on the water quality. »

No two installations are alike

Some municipalities in Valais already have several small-scale hydropower installations, such as Bagnes, where Jacquier-Luisier has just installed the municipality's eighth. The machines produced by the company also enable turbines to be installed in natural water courses, including private springs, and can also be placed in the outflows from WWTPs. « Placed end to end they combine to achieve incredible outputs ! »

In order to implement these projects and offer as wide a range of services as possible, a consortium has been established with the company Telsa to offer turnkey installations from design through to maintenance. « Our partner company produces the electrical control panels for the turbine, while we concentrate on the mechanical aspect of the installation, that is the pipework and the manufacture, assembly and commissioning of the turbine. » For the engineering work, Jacquier-Luisier also works together with the MHylab research laboratory. « Based on calculations relating to the flow rate and the height of the head, the engineers determine the diameter of the wheel, the shape of the buckets and the diameter of the injector. This enables us to complete the design and manufacture the machine to the individual specifications – no two installations are alike. »

Jacquier-Luisier also works on large-scale hydropower installations. « We are approved by the company Andritz – one of the world leaders in turbines – for the manufacture of regulators, and for certain maintenance aspects. » Claude Luisier is also involved in professional training, and is President of the Commission for inter-company training in Valais.

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Mhylab, a centre of excellence for small-scale hydroelectricity

For more than twenty years the Mhylab foundation has been developing efficient turbines adapted to the requirements of small-scale hydropower plants. Its employees have built on this experience to provide engineering and consultancy services.

Mhylab was founded in 1993 by the Association for the Development of Renewable Energies (ADER), the electricity supplier Compagnie vaudoise d'électricité (now Romande Energie SA), the Swiss Confederation and the Canton of Vaud. Backed up by its status as a foundation, the mini hydropower laboratory designs made-to-measure solutions for turbine manufacturers, independent producers, consultancies, electricity companies and local authorities. « The underlying idea behind the creation of Mhylab was to share the costs of research », says Vincent Denis, the foundation's Director. « These costs may exceed CHF 500,000 for the development of a single turbine. » His employees also use their skills in engineering and consultancy projects in the field of small-scale hydroelectric plants. They all have an academic background in engineering, with a wide range of specialisms including mechanical engineering, hydraulic engineering, fluid dynamics, energy and environmental engineering.

90% energy yield guaranteed

« Depending on the year, research represents between 20 and 50% of our activities. » Independent of manufacturers and commercial enterprises, the foundation develops made-to-measure turbines in its laboratory. In order to validate their performance, trials are carried out on a test bench. « Manufacturers come to us asking if we can pre-dimension a turbine for them, define its properties and indicate the relevant performance guarantees, having regard in particular to the characteristics of the site. This then enables them to work out the cost and submit their quotation to their client. Where appropriate, we then conclude a contract with the manufacturer to provide definitive plans for the machine, to guarantee its performance and hydro-dynamic properties. » Around twenty turbines are designed each year by Mhylab, either for the optimisation of existing plants or the installation of new hydroelectric plants. Whether Pelton turbines, diagonal turbines, axial turbines for very low heads or pico-turbines, the machines developed by the foundation's engineers achieve a guaranteed mechanical energy yield of around 90%. They can be used to equip installations for heads from 1.5 m to more than 700 m, with flow rates between 10 l/s and 10 m^3/s and outputs ranging from 20 kW to 4 MW.

Forty per cent of the consulting and engineering activities are carried out abroad, in cooperation with civil engineering practices. In particular, the foundation is currently involved in several projects on the African continent together with a Belgian partner. « We always have around thirty projects on the go. » The skills at Mhylab extend from site identification and feasibility studies, the preliminary project, the application for consents, the call for tenders, and monitoring of the manufacturing process, all the way through to assistance with the commissioning of installations. « We can take charge of one or more aspects of a project, depending on what is required. »

Whether the foundation handles one or more of these stages, it concentrates its activities on the equipment-related aspects. « We concentrate on the fields where our expertise is greatest, that is those connected with turbines, generators, control systems and auxiliary systems. » Mhylab also works together with additional consultancies. « We have our preferred partners, but we also remain flexible so that we can adapt in the best way possible to our clients' requirements. »

Mhylab mini-hydraulics laboratory

1993

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Fluid mechanics by Optydro Concept

This start-up was launched in 2013 in the field of small-scale hydropower. Specialising in the design of wheels for hydraulic machinery, it is also developing an ambitious project involving water-current turbines for use in rivers, in partnership with the HES-SO Valais-Wallis and the EPFL.

This young company offers expertise in the field of hydraulic machinery for small and medium output projects. « We carry out numerical simulations of fluid flows in hydraulic machinery and design turbines adapted to the hydrological specifications of the client's site, » explains Sébastien Alligné, one of the founders of Optydro Concept.

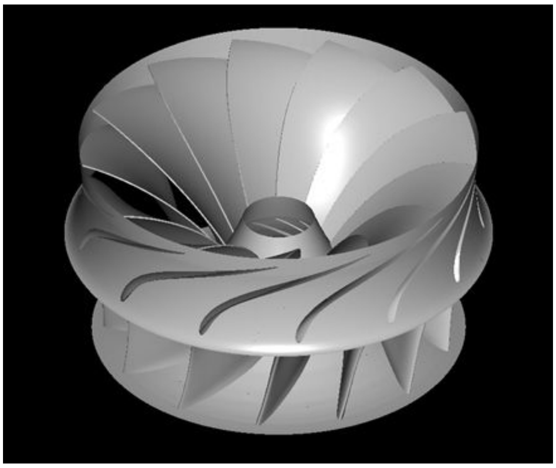
A graduate of the INPG (Institut National Polytechnique de Grenoble) and the EPFL in hydraulic machinery, he is working on several commissions alongside Jean-Louis Kueny, Emeritus Professor at the INPG and specialist in the optimal design of hydraulic machinery. Their research focuses more specifically on mini hydropower, and their skills are in demand in this field.

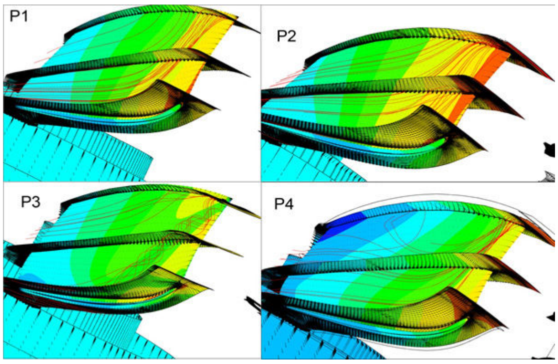
« We work for machinery constructors, at the moment mainly in France. » More specifically, the Optydro Concept engineers design Francis type turbines suitable for medium head sites and, on request, also design Kaplan and bulb type low-power turbines. « We give the constructor the geometry of the turbine, by means of 3D digital documents. » All the analyses – of flow rates, pressure fluctuations and vibrations induced in the machine and the hydraulic circuit – are rigorously taken into account in order to optimise the performance of future installations, or existing installations in course of renovation. « At our clients' request we can offer solutions to optimise not only the turbine, but also all the surrounding components. »

Water-current turbine patent applied for

Another major direction of the start-up's development is the design of a water-current turbine for use in rivers. « We have submitted a provisional patent application and have to validate our concept by August 2014. » Carried out in close collaboration with the HES-SO Valais-Wallis and the EPFL as part of The Ark Energy programme subsidised by the canton of Valais, this research should enable the development of horizontal-axis water-current turbines that have properties approaching those of wind turbines. The principle is to convert the kinetic energy of a river's water by means of a submerged hydropower turbine on the river bed. « This is also small-scale hydropower, but one where there is no water drop, or head, as is the case with pumped-storage hydroelectricity plant. In the absence of potential energy, it is only possible to rely on the kinetic energy resulting from the river's flow speed.

The challenge lies in harnessing as much of this energy as possible, a goal that our concept should enable us to achieve. » This technology has already been tested by off-shore marine water-current turbines that harness the energy of marine currents, but it has not yet been widely marketed for use in rivers.





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RWB Groupe SA, for the respectful use of natural resources

Founded in 1938 in the field of engineering, the RWB Group has gradually come to specialise in renewable energies. These include mini hydropower, a sector in which it has orchestrated the completion of thirty installations over the last six years.

RWB employs its skills in fields as varied as planning and development, water, the environment, civil engineering and energy. The group, made up of five branches, some of which are spread over several sites, draws on the multidisciplinary skills of its employees, 65% of whom are engineers, to ensure the successful completion of its projects. « Our areas of activity are not rigidly defined ; several of the group's units are often called on to work together on a single project, » says Patrick Houlmann, the group's commercial director. This global, multidisciplinary approach enables RWB to follow a project through from start to finish, from the feasibility study, through the preparatory work and site integration, to monitoring the construction site.

« The installation of mini hydroelectric plants represents 8 to 10% of our turnover. » Patrick Houlmann is keen to stress the potential of this substantial secondary arm, though it nevertheless has to satisfy the requirements of profitability. « Our engineering expertise enables us to adapt to any situation, whether the water-current turbines are located in rivers, drinking water distribution channels or the run-off from WWTPs. » Currently in the pipeline is a preliminary project concerning turbines in the Les Avants spring – the largest drinking water reservoir in Western Switzerland – on behalf of SIGE, the multi-municipality department for the management of the Vevey waters.

A pipeline beneath Lavaux

RWB has also implemented a large-scale project in the heart of the Lavaux region. Brought into service in February 2014, this mini hydropower installation required 18 months of work, the main challenge of which was the directional drilling of a tunnel 860 m in length and 850 mm in diameter to take a cast-iron pipeline of nominal diameter 500 mm – all of which took place beneath the vineyards of a region classified as a UNESCO World Heritage site. « This is the largest directional drilling operation ever undertaken in Switzerland ; the pipeline will enable the waters of the Forestay to be controlled between Chexbres and Rivaz, where the turbine has been installed. » These works were financed by Romande Energie and should enable 2.6 million kWh of electricity to be produced per annum, enough to supply around 700 households in the surrounding villages.

Here, as elsewhere, RWB relied on the expertise of its suppliers for all the technical equipment. « We determine the characteristics of the final products and then put them out to tender. » The same applies to the works, which are entrusted to a specialist company. « We undertake the site supervision ourselves, through to completion of the project. »

Independent of any pension funds or other external investors, the seven shareholders all act as directors of the group. And whatever the project, the management of RWB has at heart the principles of sustainable development. The group also supports social and humanitarian projects. « In this, our 75th anniversary year, we were able to install a water filter in Burkina Faso that operates without electricity or chemical products, and supplies a whole village. » RWB Groupe SA is represented by its subsidiary companies in the cantons of Jura, Neuchâtel, Vaud, Fribourg and Valais.

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Stahleinbau GmbH, far-reaching work on hydroelectricity

Based in Stalden in Upper Valais since 1984, this company has long since proved its worth in the field of large-scale metallic structures. It also uses its skills in engineering and the manufacture of parts for small-scale hydropower installations.

Following the retirement of Peter Wenger, the company's founder, in November 2013, it was a young, highly-motivated team who took up the reins of Stahleinbau und Maschinen AG, which became Stahleinbau GmbH last January. His daughter, two engineers and the shop foreman are now at the helm of this company based in Upper Valais. Originally specialising in metallic structures and the supply of equipment for tunnels and underground works, Stahleinbau GmbH has gradually diversified its activities, to include in particular the manufacture of equipment for rail transport and the hydropower industry. It is now mainly active in metallic structures, large-scale mechanical engineering and hydropower machinery. « Hydropower represents about 60% of the company's activities, with a major part of that for small-scale installations », says Nino Brunner, mechanical engineer and project manager. The skills of the Stahleinbau GmbH employees also enable them to work both in the maintenance of existing installations and the commissioning of new ones. « We are involved with about a dozen small-scale hydropower installations per annum, both for small projects and for programmes that may extend over several years. » Backed up by its experience, the company is active throughout Switzerland and beyond. « We provided four installations for EDF in France last year. »

Automation of grit chambers

In practice, Stahleinbau GmbH is involved from the planning phase of a small-scale hydropower project, for which it then undertakes the design (dimensioning of the installation, engineering calculations and technical drawings). « We are able to manufacture numerous mechanical elements ; essentially, we supply the shut-off devices, such as butterfly valves and hollow-jet valves, as well as water intakes and the associated steel equipment, penstocks and grit chambers. » The Stahleinbau GmbH specialists also assemble, commission and carry out maintenance on these installations.

Always on the lookout for innovations that will enable them to increase the energy yield of hydroelectric turbines, the company's engineers also work on research projects. One of these resulted in the design of an automatic purge system for a grit chamber, in partnership with The Ark Foundation for Innovation in Valais, the Hydraulic Constructions Laboratory at the EPFL and the HES-SO Valais-Wallis. The grit chamber is a very important element of hydropower installations. With one fitted to each water intake, it removes any water-borne sand and organic matter such as leaves, before the water is delivered to the turbine, thereby preventing damage to the machine. While the purge of a grit chamber is currently undertaken manually, the research carried out by Stahleinbau GmbH and its partners has enabled them to design an automatic purge system which uses less water during the process and reduces the maintenance costs of a hydropower installation. « Our technology works, and we are now intending to carry out full-scale practical tests. »

Stahleinbau GmbH

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Vogel Pompes SA, at the heart of mini hydropower installations

Vogel Pompes SA is a company whose activities are concentrated on the sale, commissioning and maintenance of all kinds of centrifugal pump for the construction sector, industry and local authorities. Some of their machines are used in small-scale hydropower plants

In 1963, the Austrian company Ernst Vogel Pumpen GmbH, which specialises in the manufacture of centrifugal pumps, founded a Swiss subsidiary for the sales and servicing of its products. Operating independently since 1985, Vogel Pompes SA is still involved in the sale of pumps for all kinds of system – drinking water pipelines, waste water, industry, construction – whether or not fitted with submersible motors, horizontal or vertical, lineshaft, etc. « These machines are manufactured in Austria or northern Italy, » says Laurent Panchaud, the company's director. His employees also carry out the maintenance, repair and servicing of all brands, either in their workshops or onsite at the pumping installations. « Mini hydropower still only represents a small proportion of our activities, but recently we have vastly increased what we offer in this sector, in order to reinforce our presence. » For example, a reversible pump can be used as a turbine to produce electricity. « Our machines are traditionally used for raising water, whereas in mini hydropower it is a matter of recovering the energy from falling water. »

Optimising existing systems

Several small hydroelectric plant projects have already been equipped with reversible pumps supplied by Vogel Pompes SA. One of these is the Bourguillon pumped-storage hydroelectricity station. Located in the canton of Fribourg, it is operated by the town's municipal utilities. The turbine installation has a rated power of 22 kW. « This project is a very interesting example of the potential of mini hydropower. All we needed to do was add some elements to an existing system to recover the energy of the installation for electricity generation. An investment of just CHF 150,000 has funded these optimisation works. » The company has also fitted pumps to the drinking water pipeline of Onnens-Sainte-Croix. « The overflow descends in three stages; we installed a reversible pump at each level. » Again this enabled a large part of the energy hitherto lost at the installation to be recuperated.

Vogel Pompes SA have sold more than ten machines for this kind of purpose in Western Switzerland. « We deal exclusively with the hydraulic parts; all the control and regulation aspects are undertaken by other companies. » In addition to the actual sale of the turbines, the company also provides advice on their dimensioning.

« We only provide reversible pumps that are suited to various installation types with a constant flow rate, up to 3,000 m³/h. » Although these pumps can deliver an output of up to 1 MW, the plants installed to date do not exceed 200 kW, for heads of 300 to 400 m.

« Our company is particularly keen to contribute to the development of these green alternative energies. We want to participate in more and more projects of this kind. » Ecological concerns are not only of commercial interest to Vogel Pompes SA. Last year, the company fitted 680 photovoltaic solar panels to the roof of its own headquarters. « It's a mindset. »

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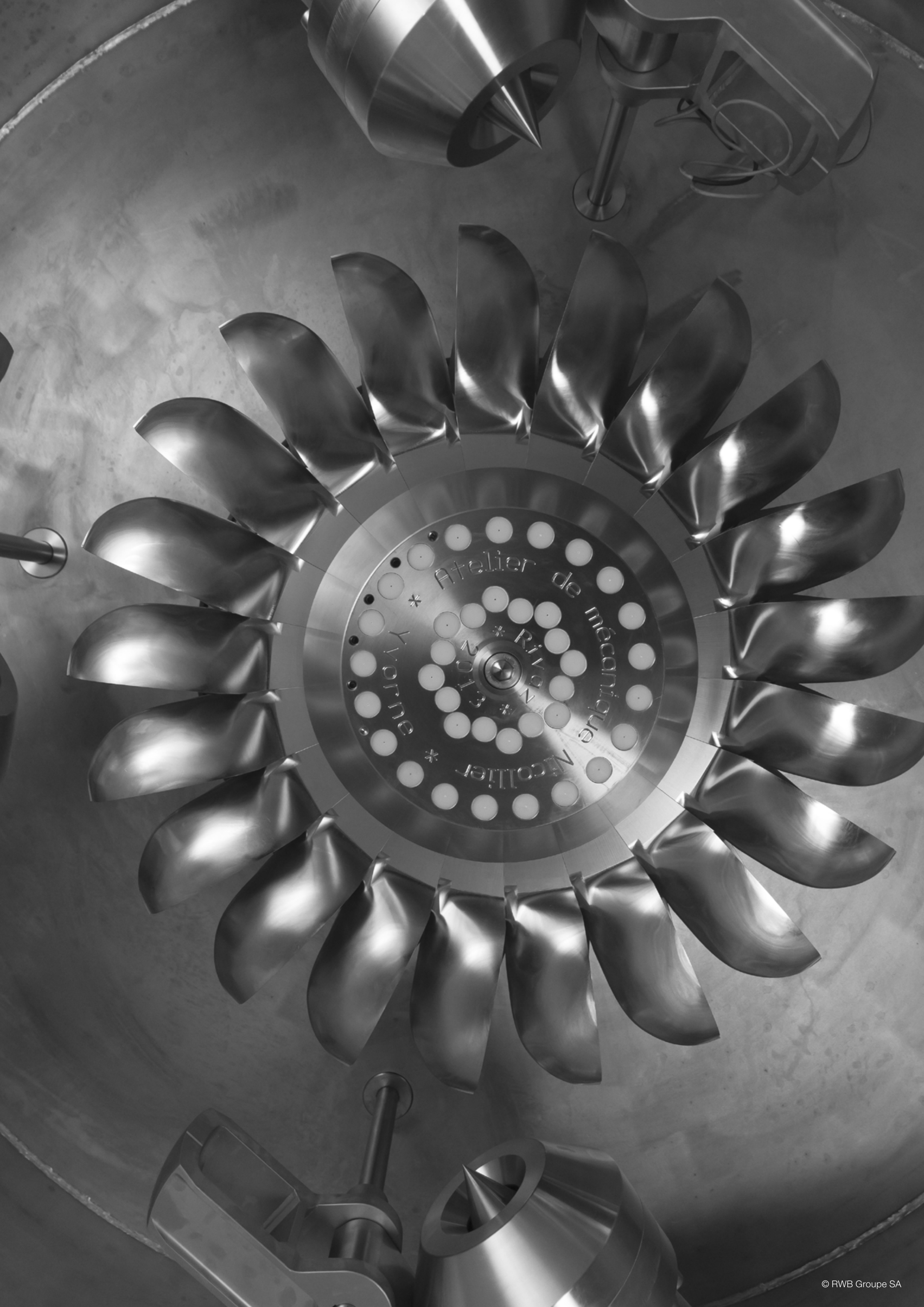
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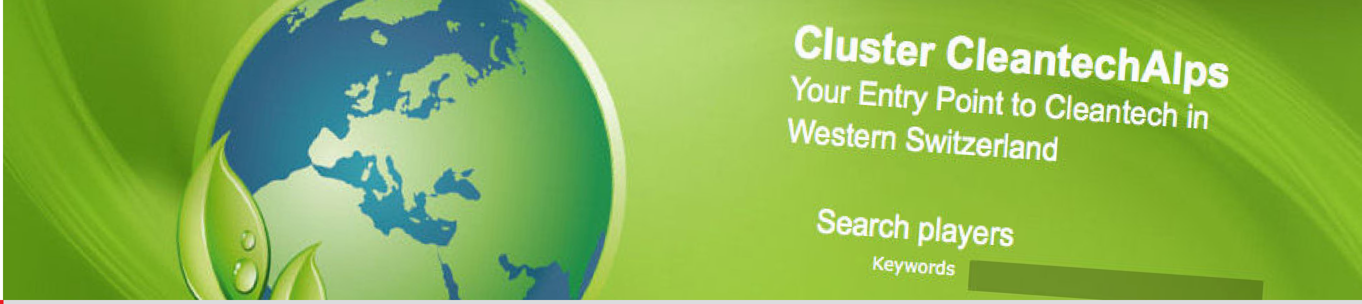
CleantechAlps, your preferred partner for all issues related to clean technologies.



CleantechAlps, serving businesses and institutions

CleantechAlps, the platform dedicated specifically to clean technologies in western Switzerland, was launched at the initiative of the seven cantons of western Switzerland. It is supported by the State Secretariat for Economic Affairs (SECO).

The missions of CleantechAlps are as follows:

- To ensure the reputation of and to promote western Switzerland as a European hub for clean technologies related issues.
- To enable the introduction of cleantech players on international markets.
- To develop synergies between regional and national cleantech stakeholders.

CleantechAlps is the intercantonal driving force behind the development of cleantech and is the enabler at the interface of the economic, academic, financial and political worlds. In this context, CleantechAlps is definitively the main point of contact for coordination in western Switzerland of national initiatives such as the «Cleantech Switzerland» and «Cleantech Master Plan».

Join CleantechAlps

Businesses and institutions of western Switzerland who wish to join CleantechAlps and benefit from good visibility may do so simply by e-mailing info@cleantech-alps.com (free subscription).

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CASE STUDIES

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« For a better understanding of cleantech in western Switzerland »

« Water treatment in western Switzerland »

« Waste recovery in Switzerland : a model to be emulated » *new*

They are available on : www.cleantech-alps.com/study

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CleantechAlps is an initiative of the Cantons of Bern, Fribourg, Vaud, Valais, Neuchâtel, Geneva and Jura.
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Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Economic Affairs SECO

Cleantech ecosystem in Switzerland : who does what ?

Incubators & science parks

- TecOrbe (VD)
- BlueFactory (FR)
- BlueArk (VS)
- Neode (NE)
- Cleantech Genève (GE)

Ambassadors project

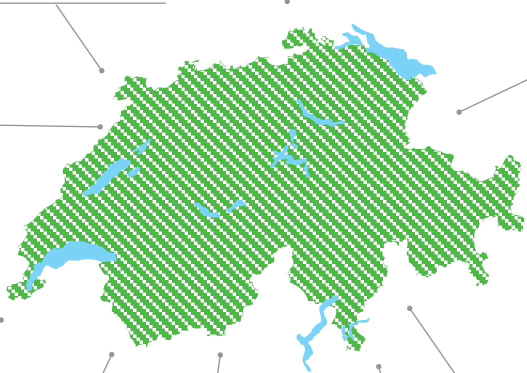
- PlanetSolar
- Solar Impulse
- Icare
- Biomobile
- Monotracer
- Monte Rosa Hütte

Confederation

- SFOE
- FOEN
- SERI
- SDC
- SECO
- CTI

Enablers

- **CleantechAlps**
- ÖBU
- Swiss Water Partnership



Academic institutions

- EPFL/ETHZ
- Universities
- Universities of Applied Sciences (HES)
- EMPA
- PSI

Industry

- SME Start-up
- Big companys
- Engineers'offices
- Industrial services

Semi-public organism

- Cleantech Switzerland
- Swissnex
- Swiss Business Hub
- Switzerland Global Enterprise

Associations

(sectorial theme)

- Swiss Solar Technology Cluster
- Swiss Solar
- SuisseEole
- energie-cluster
- eco-net

Lobby

- Swiss Cleantech
- AEE
- Swissmem

Local actors

- Cantons
- CoC
- Cleantech Fribourg
- Cleantech Cluster ZH
- i-net
- Cleantech Cluster ZG
- Cleantech Aargau …

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2. These figures are based on estimates made by the cantons, using as a basis projects which have demanded a cost-based feed-in tariff (FIT).

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4. Document available on request from info@blueark.ch

5. Available on: http://infoscience.epfl.ch/record/176337?ln=en

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11. Michel de Vivo, Secretary-General of ICOLD, Session 16, HYDRO 2011 Conference, Prague.

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