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# Granting access to a high-level postgraduate study program in hydraulic engineering

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## Abstract

This article focuses on the accessibility of postgraduate education in hydraulic engineering sciences in order to satisfy the actual and future needs of the society regarding the vital functions of water and the protection of humans against its destructive forces. Engineers from developing and transition countries as well as from the industrial world benefit from two different ways to access these studies. Swiss and EU graduates within a limited geographical area follow this part-time course keeping their professional activity, while international students normally have to reside in Switzerland at their own expense. In order to finance their studies and to gain professional experience, they have the opportunity to work as part-time trainees in industry, engineering companies, public administration or research institutions. The hosting institutions, in a limited number, will remunerate the international trainees with a bursary allowing them to cover the living expenses in Switzerland and to reimburse the enrolment fees by monthly payments. The Swiss Commission for Research Partnerships with Developing Countries financially supports the training of students from economically disadvantaged countries; hence enabling them to more efficiently find appropriate solutions in their countries.
The offered postgraduate studies in hydraulic schemes at the EPFL propose some 600 hours in total on a one-day a week basis over two years. The modules are based on academic teaching, offering an adequate balance between theoretical and practical training. The program combines conceptual thinking with strong practical focus. It covers all the domains in hydraulics related to structures and schemes in which needs have been identified. It focuses particularly on subjects related to the sustainable development and use of hydropower production; protection measures against floods and land erosion; water supply and wastewater management; and storage of water. Both Swiss Federal Institutes of Technology and a group


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of other well-known Swiss and European academic and non-academic institutions ensure the teaching.
Most of the alumni benefited from a promotion inside their pre-study job, changed career with a position of higher responsibility or even created their own business. The international students mostly returned home. The effective contribution of the program for the professional career of the participants is considered significant. International graduates are predestinated to take important positions in their countries, especially in developing countries and they will be the ambassadors of the EPFL and more generally of the Swiss economy.
For the future, one main objective of the organizers is to continue to attract engineers from all significant origins and countries and thus to ensure the right to access the high-level study program. One idea lies in developing the sponsoring of students by Swiss or foreign engineering companies, which cannot offer paid training places at their own offices. The students will consequently be hosted by the EPFL offering its infrastructure and supervision by the locally available academic team of teachers, while working on a subject either defined by the hosting institution or the distant sponsor. Another idea to develop is to explore the possibilities in the domain of ICT for education and distant learning.

## Introduction

Since antiquity, hydraulic structures created by man have had the objective not only to use the vital functions of water but also to protect humans against its destructive forces. The importance of the necessary infrastructures, which allow the supply of the world population with water and energy in order to fight against famine and poverty, does not need to be stressed again. They are more particularly used for the following purposes:

- water supply for agricultural, domestic and industrial use
- development and use of hydropower for electricity production
- waterways for the transport of persons and goods
- protection against floods and land erosion
- evacuation and restitution of wastewater
- storage of water

All these actions and constructions oriented towards mastering the water cycle have contributed to the development of engineering techniques in hydraulics in conformity with sustainable development needs. The transfer and constant development of this heritage are the principal missions of universities. The latest university-based scientific developments need to be enlarged by state-of-the-art technological applications used by the private sector, completed by public administration requirements, thus forming a real compilation of the key competencies for hydraulic engineers. Bringing all these real-life partners together in a single postgraduate course syllabus, allows the valorization of the competence of the numerous involved Swiss and foreign institutions that are the holders of an important potential of knowledge and know-how in hydraulic schemes.
Even though the task ahead is and will remain gigantic, it is the goal of this course to give the required knowledge, training and education through multicultural teamwork to a selection of specialists, to make them ready to strengthen the teams already in place worldwide in the domain of hydraulic schemes. Engineers graduating from this course should be prepared to bring answers and solutions to the demand in infrastructures in order to satisfy the vital needs of humanity by a global and multidisciplinary approach.
In 1999, after having defined the needs for the 21$^{st}$ century, the Swiss Federal Institute of Technology Lausanne (EPFL) has accepted the challenge by organizing postgraduate courses


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on hydraulic schemes. Due to its geographical situation in the center of the Alps, Switzerland, together with its neighboring countries, has always been considered as the water tower of Europe and therefore, is logically a well-placed country to acquire high competence in this field.
On 13th September 1999, 27 eager experienced engineers attended for the first time the new postgraduate cycle that brought them back to the school bench for a tough day of brainwork. For many, their school days were far behind and it was a great challenge to become a student once again while still leading a professional life in parallel. In 2001, 26 new students joined us to restart the study cycle for the second time.

**Target audience and effective attendance**

Recruitment of participants targets public institutions, consulting engineers and companies that operate and own hydraulic schemes. In particular, the course is intended for:

- consulting engineers working in the field of water
- private sector managers and engineers
- engineers of public administrations in charge of hydraulic structures and schemes
- young engineering professionals wishing to specialize in hydraulic structures and schemes

In order to answer the question where the students come from, we briefly retrace the hydraulic situation regarding energy production of the countries of origin of the students.

- Algeria (2 students) has 7 dams higher than 60 m under construction with the purpose to satisfy the important need of water for irrigation.
- Austria (1), which produces 65% of the electricity demand by hydropower, has still a significant potential between 16000 and 18500 GWh/year.
- Benin (1) until now almost doesn't make use of its hydropower potential.
- Burkina Faso (1) has only 15 % of the hydropower potential used.
- Brazil (1) produces 94 % of its electricity consumption by hydropower and has still the largest hydropower resources in South America. Only around 40 % of the economically feasible potential has been developed so far, but with already 139 large plants in operation. There is more than 5000 MW of new hydropower capacity planned to be implemented soon.
- Germany (1) has 2 dams about 100 m high under construction, one for a pumped storage scheme, and the other for a drinking water reservoir.
- Madagascar (2) makes use only of 1 % of its hydropower potential but produces already 72 % of the electricity consumption by hydro.
- India (2) with 92 % of the 4000 existing dams built for irrigation. With the increase in population, the need for fresh water from now till 2025 will be so important that the construction of hydraulic schemes will have to focus mainly on storing and transport of water.
- Iran (5) has a real challenge for dam designers, 40 dams higher than 60 m are presently under construction. Several projects are foreseen till 2020, mainly multi-purpose projects orientated towards flood protection, irrigation and electricity production.
- Italy (2) has used two thirds of its hydropower potential. The future development is related to the water demand for drinking, industrial use and irrigation.


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- Kosovo (1), once the political problems are solved, has numerous infrastructures in all domains to be rehabilitated by engineers.
- Nepal (2) is the water tower of the whole area with a hydro electrical potential 5 times higher than in Switzerland, representing a possibility in supplying India with water necessary for the irrigation of millions of hectares.
- Peru (1), with only 5 % of the hydro electrical potential developed, has 48 large dams in operation at the moment.
- Portugal (1) uses only 60 % of its economically feasible hydropower potential and has high future demand for irrigation water.
- Senegal (2) has a hydro electrical potential scarcely developed.
- Tunisia (1) produces less than 1 % of its electricity by hydropower and needs reservoirs mainly for irrigation and flood protection.
- Turkey (1) has actually 60 dams higher than 60 m under construction and will considerably increase its hydropower production in future combined with irrigation projects.
- Switzerland (some two dozens), to conclude this world trip in relation with the students enrolled, has 200 large dams in exploitation and more than 500 hydro electrical power plants able to produce about 60 % of the electricity demand. The hydro electrical development is limited today with almost 90 % of the economically feasible potential already exploited. In the years to come, the challenge will be to rehabilitate and optimize the existing power plants.

In conclusion to this enumeration of origin of the 53 students who participated in the postgraduate studies in Lausanne, we may point out that all the participants put together speak more than 18 different languages to which an important number of dialects should be added. To the classical activity of an engineer, one should thus add the use, other than one's mother tongue, of several foreign languages, the ability to work in a team and the habit of being tolerant towards other cultures. All these factors contribute in reinforcing bonds between countries and people.

## Offered training and courses

*Course contents*

The course is divided into modules of 60 to 80 hours each. They are organized into sub-modules of 16 to 32 hours each on a one-day a week basis. The modules are based on academic teaching, offering an adequate balance between theoretical and practical training. The detailed course contents are illustrated in Fig. 1. The program combines conceptual thinking with strong practical focus. It covers all the domains in hydraulics related to structures and schemes in which needs have been identified. The course organizers will, in certain cases, adapt the contents in function of new challenges in the field.


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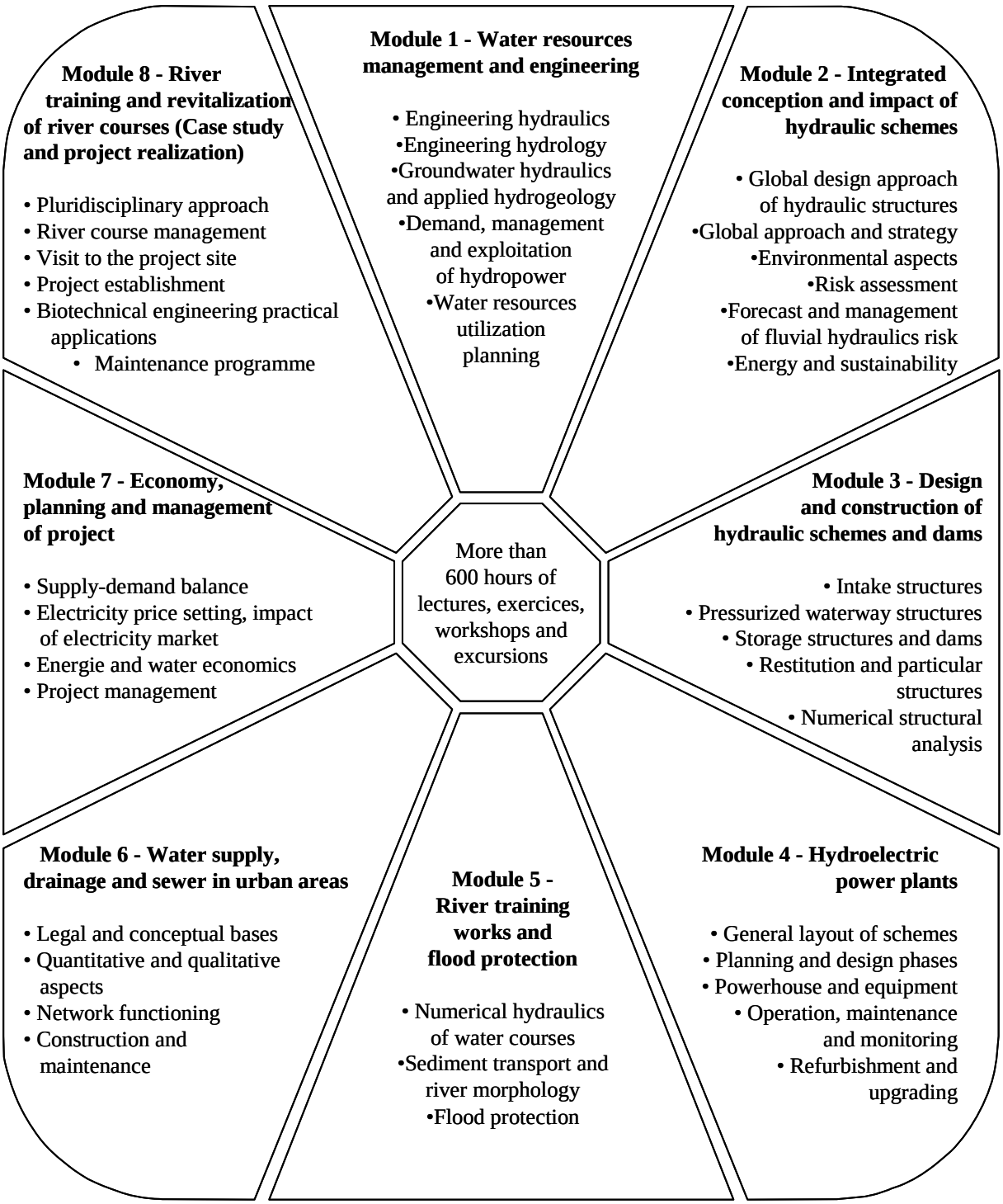


Fig. 1: Detailed course contents, divided into 8 modules and more than 40 sub-modules

*Course languages*

Together with the neighboring University of Lausanne, the EPFL constitutes the most important center for university-level teaching and research in French-speaking Switzerland. As a great number of teachers come from the non-French speaking part of Europe, they teach in English. The official course languages are therefore French and English and a good command of both languages is necessary to follow the course. Students can improve their French or English by attending classes of all levels at the language center of the EPFL.


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These postgraduate studies are an excellent opportunity to improve one's knowledge in both languages, which represents a great asset for professional activity on an international level.

*Knowledge assessment*
Assessment is generally carried out through written examinations for each module during the cycle. Each exam corresponds to a certain amount of credits. To proceed with the final diploma project (see hereafter), the students must obtain a minimum of 60% of the total amount of credits. The credit system is in conformity with the European Credit Transfer System (ECTS). ECTS credits reflect the quantity of work each course requires to complete, including lectures, practical work, seminars, private work and examinations or other assessment activities. In ECTS, the 60 credits awarded for the complete postgraduate course represent one year of full time study in terms of workload, at which 40 credits are added for the diploma thesis.

*Postgraduate diploma project*
The lectures of modules 1 to 8 are followed by an individual postgraduate diploma project of approximately 400 hours, respectively 40 credits. Students having achieved good results during the course are authorized to proceed with the postgraduate diploma project during the second year of the course. The project will lead to a dissertation, to be presented to a board of experts. The project must be finished and presented at the latest six months after the end of the courses.
The participants normally choose the topics. Their current employer or hosting institution for student trainee helps them to find a subject of mutual interest, which may be integrated into their present work. The subject is supposed to cover at least one subject taught during the two years lectures. As the range is very wide, there was no problem finding a suitable project for each student. The selected, approved and defended topics covered:

- 14 projects on river training works and flood management (including creation of a new water course on an industrial site; restoration of fish migration; design of flood derivation works; morphological processes during floods; debris flow modeling; revitalization of river courses; sediment potential estimation of mountain streams; bed load management; dynamic natural risk management; hazard map and protection measures of torrents and management of hydraulic river cross-sections).
- 6 projects concerning the design, construction and exploitation of hydraulic schemes (including projects on intakes for small hydropower plants on sediment transporting rivers; theoretical approach of hydraulic head loss calculation in an unlined pressure tunnel; behavior of pressure tunnels in anisotropic permeability rock mass; general hydraulic system design; sediment evacuation measures from reservoirs through the power intake and safety of overflow embankment dams).
- 2 projects in the field of economy, planning and management of projects: investigating the financing of medium size hydropower plants in Nepal and the optimization of the energy production from multiple hydroelectric schemes.
- 2 projects in the domain of water supply systems in urban areas with one study on the hydraulics of a vortex shaft with tangential inlet and the other study on the financing of water supply systems by the private sector.
- one project relative to the design and construction of a new open-air hydraulic testing facility.

Description of the projects can be found on the Website of the postgraduate studies (http://lchwww.epfl.ch/postgrade/). All the above-mentioned projects include theoretical development and practical application. Through the necessary research work, the students


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should be able to identify and assess issues in their chosen field objectively and rationally, to adopt an enquiring, analytical, and creative approach to problem identification and solution, and finally present their work in the form of a clear and concise dissertation and an oral presentation. The major purpose of the oral defense is to have the student demonstrate his ability to justify the selected procedures, to illustrate the obtained results, and confirm the interpretations of the study, making use of modern presentation techniques. The student has then the opportunity to answer the questions raised by the board of experts. The final synthesis report must be presented ready for submission to be published in a scientific journal.

**Cost of the studies**

*Tuition fees*

The student enrolment fee for the 2003-2005 edition of 3'500 Swiss Francs (CHF) per year covers registration costs and contribution to the expenses of the course. They are divided into an enrolment tax of 550 CHF and a contribution to the costs of 2'950 CHF. The enrolment tax goes directly to the EPFL central accounting services and contributes to compensate the use of the general services of the EPFL. Counting with 25 fully enrolled students, the annual income amounts to 13'750 CHF for the EPFL and to some 73'750 CHF for the contribution to the costs. To proceed with the Postgraduate diploma project, an additional 2'000 CHF is due mainly to cover the expenses related with the projects.

In the 1999-2001 edition, the course counted 5 additional students following 8 single modules. In the 2001-2003 edition, 6 students followed one or more of the 8 single modules. Their payment consisted of a contribution to the expenses. In response to the new policy of the EPFL presidency; the expenses of this kind of training should be more and more covered by the participants, the contribution for the 2003-2005 edition amounts to 1'500 CHF per module.

*Sharing of the cost*

The cost of the offered postgraduate education is at present shared between the EPFL and the participants. The global expenses are estimated at around 290'000 CHF per year. It includes the salaries (~61%) of the general manager and the part-time secretary, the payment of the lecturers (only ~26%), and the exploitation costs of the course (~13%) taking into account course documentation printing costs, excursion costs and expenses arising from institutional contacts and travels. The contribution dedicated for the payment of the lectures can be kept pretty low, as lecturers coming from both Swiss Federal Institutes in Zurich and Lausanne instruct normally at no cost for the course management, because postgraduate teaching is usually part of their professional duties. As already mentioned, the general services of the EPFL are freely available to the course organizers. The hosting Laboratory of Hydraulic Constructions (LCH) houses and covers the operating costs of the secretariat. Classrooms are available free of charge from the EPFL. All these costs are difficult to estimate, but with the ongoing process of privatization touching even higher education, they will have to be taken into account seriously in the future.

Other financial sources or sponsors to cover the course costs are not available at the moment. The Swiss industry, administration and engineering companies are already seriously contributing by assuring some 13 part-time remunerative training places (see below) for the 2001-2003 edition, with a total annual amount of about 280'000 CHF.


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*Cost of living*
The cost of living in Switzerland, on average, is relatively high compared to the rest of Europe and the world. For basic expenses such as food, rent and transportation, students will usually pay more than in their home country. The absolute minimum amount required to live in Lausanne is about 1’500 CHF per month. All this is depending of course on the personal spending habits of each student.
Also, as foreign students are generally not allowed to work during their stay in Switzerland, no additional income can be earned. Foreign students must have sufficient funds to study at the EPFL. They can expect almost no financial aid, from either official or private sources. So how can students follow this postgraduate course, without having the necessary financial background?

**Granting initial access**

As mentioned before, international students do not receive any scholarships from Switzerland except if they are participating in some official (e.g. the SOCRATES-ERASMUS) program. The best idea is to look and apply for any possible scholarships in the home country before applying. But even this option is not really encouraging, as funds are difficult to obtain, especially in some cases one year before the course starts.
Therefore and except some initial self-financing in order to come to Switzerland, the organizers have made-up a system of remunerative training places for foreign students unable to pursue with their professional activity during the course.
The course management can organize a limited number (some 10 to 15) of part-time remunerative training places in the industry or in a research institution. Paid-training allows the candidates to gain additional professional engineering experience during the study course. Students normally get the opportunity to carry out their diploma work in the hosting institution. Paid-training is limited to the duration of the course at the most, including the time necessary to complete the diploma work and it is granted in priority to non-Swiss resident candidates. Paid-training normally takes 50% to 60% of the participant's time. The hosting institution assures a net bursary of 1'750 to 2'200 CHF per month. This amount is meant to cover the living expenses in Switzerland. As the money transits via a fund account at the EPFL, it is officially considered as EPFL bursary, and therefore free of income tax and social charges. Such a paid-training is closely linked to the course and can be offered only when the student attends the course regularly and meets the assessment regulations. It is considered as part of the university training and therefore allowed to be undertaken with the normal student visa.
When receiving the enrolment application forms, the candidate's profile is sent to potential hosting institutions, which can select the student with the appropriate profile, taking into account professional and academic education, language skills and origin. The latter applies especially for Swiss engineering companies with international relations, who desire to establish valuable contacts in the corresponding countries. The course management normally only accepts a student who has obtained such a paid-training and who therefore has the necessary revenue for the 2-years period of the course.

The fact, that normally the full tuition fee for the first year is due before the start of the course and even in some cases necessary to obtain an entry visa for Switzerland, may reduce considerably the access for people with limited financial resources. Upon request and after an initial payment on account before the start of the course, the academic services of the EPFL,


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together with the course management, can give candidates the possibility of monthly payments of the fees after the start of the course.

**Possible help given while living in Switzerland**

The paid training program builds essentially on a national partnership with consulting engineering companies and public administration, some of them also involved in education and training during the course. Throughout the two editions since 1999, in total 26 training places could be organized. Most of them lasted during the whole 2½-year length of the course, including the diploma work. Some of them were of short duration, sometimes just linked to a certain project of the company or the diploma work. Various companies or administrations, lacking the necessary infrastructure or personal to ensure assistance for the candidates, sponsored a training place at the EPFL.

On the academic level, the following institutions offered paid training places during the course:

- Laboratory of Hydraulic Constructions (LCH) of the Swiss Federal Institute of Technology in Lausanne (EPFL)
- Laboratory of Soil Mechanics (LMS) of the Swiss Federal Institute of Technology in Lausanne (EPFL)
- The Laboratory for Hydraulics, Hydrology and Glaciology (Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie - VAW) of the Swiss Federal Institute of Technology in Zurich (ETHZ)
- The civil engineering department of the Engineering School in Yverdon (EIVD)

Training places were offered or sponsored by the following public organizations and administrations, all in charge of water related subjects:

- Sanitation Services of the City of Lausanne
- Solothurn Cantonal Office for the Environment, Solothurn
- Swiss Federal Office for Water and Geology, Berne and Bienne
- Valais Cantonal Office for Roads and Water Courses, Sion
- Valais Cantonal Service for Hydropower, Sion
- Vaud Cantonal Service for Soils, Water and Sanitation, Lausanne
- Water Services of the City of Lausanne

Some 10 consulting and private sector companies working in the field of hydraulics have also offered or sponsored some training places.

- Bonnard & Gardel Engineering Consultants, Lausanne
- BOSS & Associates Engineering Consultants, Lausanne
- Colenco Power Engineering Consultants, Baden-Dättwil
- Electrowatt-Ekono Engineering Consultants, Zürich
- Emch+Berger Engineering Consultants, Berne
- Ingegneria Maggia Engineering Consultants, Locarno
- Jaquier & Pointet Surveying and Rural Engineering Consultants, Yverdon
- Karakas & Français Geotechnical and Geostructural Engineering Consultants, Lausanne
- Stucky Engineering Consultants, Renens
- VA TECH Hydro, Vevey


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Paid-training allows the candidates to gain further professional engineering experience during the study course, and, if a suitable project is available, to have the opportunity to carry out the diploma work in the hosting institution.
The collaboration details are defined through a three party agreement, involving the student, the hosting institution and the Laboratory of Hydraulic Constructions as coordinator and mediator. The terms of the agreement deal with the following main points: purpose of the program, start and expiration of the agreement, insurance and social security issues, the bursary given to the student trainee, organizational integration of the student, supervision and possible diploma work.
The training program is set in an appendix to the agreement, ensuring that the student's work is closely related to the course subjects, to the abilities of the students and the possibilities of the hosting institution. The organizers actively encourage the participation in the common, also non-work related activities of the hosting institutions by the students.

The student trainee program is a great success. It has been put-up within a very short time, mainly thanks to existing contacts of the course management and the direction of the Laboratory of Hydraulic Constructions with their academic, public and industrial partners. Nevertheless, most of the training programs only start one or two months after the arrival of the students, and consequently the bursary. At the start of the first edition in 1999, this fact caused some problems to students without sufficient financial resources at the beginning, until the first money arrived.

For the second course, the Commission for Research Partnership with Developing Countries (KFPE) supported the first month of the living costs in Switzerland through the Program 'Echanges Universitaires' (University Exchange, see below). For participants coming from developing countries (DC) the first month was not secured by the trainee program and caused severe problems to some of the participants. Since the students had already paid their own flight tickets, KFPE acknowledged this commitment by providing some funds as described above. In addition, in the second year KFPE supported the participants again by paying parts of their traveling costs within Switzerland. One of the main tasks of KFPE is to support initiatives, which strengthen individual or institutional capacities in developing or transition countries (TC).

*What is KFPE (www.kfpe.ch)*
The main aim of KFPE is to support research partnerships with DC and TC. The Commission ensures that ethical principles are followed, quality is maintained and that the interests of all partners in partnership projects or programs are taken into consideration. KFPE is also engaged in Swiss scientific policies and is committed to promoting the interests of researchers and their affiliated institutions on both a national and international level. It works under the umbrella of the four Swiss scientific academies, or CASS (Council of the Swiss Scientific Academies; www.cass.ch).

The activities of KFPE are based on the following premises:

- research is an integral part of development. It can be used to help solve urgent problems from international to local levels;
- above all, basic research capacity needs to be developed and firmly anchored in developing and transition countries;
- this can be accomplished through long-term development-oriented research partnerships.


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KFPE has the following activities:

- **convincing** the scientific community, politicians and the general public of the urgency and importance of carrying out research in partnerships with developing and transition countries;
- **evaluating** research partnerships, and publishing criteria and basic principles for the implementation of projects in partnership, trying to ensure that projects are of high quality, that ethical principles are observed, and that the interests of all partners are taken into consideration;
- **organizing** events and publications on partnership in research, encouraging the interest of younger scientists, offering a forum for the exchange of information, and supporting the members in their efforts to disseminate and consolidate the idea of research in partnership, and put it into practice;
- **building** bridges between North and South, and between research scientists and people working in development.

In addition, KFPE formulated "Guidelines for Research in Partnership with DC: 11 Principles", which are available free of charge in five languages.

Members of the Commission include Swiss and foreign persons with experience in research partnerships with developing and transition countries. The associated members currently include about 65 Swiss institutions of research, research promotion and development cooperation, as well as federal offices and foundations.

*Program 'Echanges Universitaires (www.kfpe.ch/projects/echangesuniversitaires.html)*
As from 2001, the KFPE administrate and mandate two SDC research programs (SDC: Swiss Agency for Development and Cooperation). One program promotes short exchanges or collaboration between Swiss universities or educational institutions and research institutions in economically disadvantaged countries. Interaction of this kind should contribute to develop the educational, scientific and training capacities of the persons and institutions involved, as well to strengthen the overall research capacity of the partner country. Another program supports young researchers studying in Switzerland during their field visits in DC or TC. In addition, the exchange program will offer Swiss universities and research institutions the opportunity to reflect on their experience of the problems of economically disadvantaged countries, and also enabling them to more efficiently contribute to finding appropriate solutions.

**Program coherence to the needs of developing and transition countries**

As seen in the paragraph related to the origin of the students, the direct professional needs are very wide but real. The course objectives should satisfy the present and future needs in the field of hydraulic engineering worldwide by the means of excellent quality teaching. Therefore the program covers all the domains in hydraulics related to structures and schemes in which requirements have been identified. It focuses particularly subjects related to the sustainable development and use of hydropower production; protection measures against floods and land erosion; water supply and wastewater management; and storage of water.


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*Sustainable development and use of hydropower production*

In the field of energy policy today, the developing countries are mostly not prepared to take into account binding commitments to reduce their greenhouse gas emissions until developed countries show progress in reducing their own emissions and in fulfilling their commitments to assist them with financial resources and technology transfer. The proportion of hydropower in comparison with other sources of electricity is approximately the same in all the continents (15 to 20 percent) with the exception of South America, which has 77 percent of hydropower. At the level of individual countries, it is clear that hydropower plays a major role in many of them. In 68 countries, hydro produces more than 50 percent of electricity; for 22, more than 90 percent and for 13, practically the total.

Countries with hydroelectric potential have in general understood very well the value of developing it. This creates a possibility of wealth for them, but it is also an advantage for the rest of the world, avoiding the combustion of fossil fuels. As it has been the rule for the last few decades in Europe and Switzerland, master of the techniques in hydro development is not sufficient to realize it. Even if the advantages of renewable energies such as hydropower are quite clear, it is nonetheless necessary for the acting engineers, formed during this course, to be conscious of the possible conflicts while planning and constructing new dams and hydropower plants. Good engineering has to be combined with social, economic and policy aspects. The related problems, such as resettlement, landscape destruction, regional water balance upset or lack of financing possibilities, etc. often attracts more attention than the purely technical solutions. As far as environmental impacts are concerned, they have to be taken into account seriously from the very beginning of a project, in conformity with international and national standards, and their solution should not be left to politicians and NGOs only.

Therefore teaching includes not only the purely technical aspects such as design of intake structures, pressurized waterway structures, storage structures and dams, appurtenant and other particular structures, but also water resources management and utilization planning, demand and exploitation of hydropower, global design approach and strategy in hydraulic schemes, environmental and risk assessment and sustainability of projects.

*Protection measures against floods*

This other major issue where hydraulic works are widely used, is not so heavily publicized as the energy sector mentioned before. Except severe large scale floods, that attracts the attention of a great number of countries and which images are widespread, slow motion activities such as land erosion, natural river destruction or settlements in flood zones passes rather in the unconscious. But the need of understanding the underlying hydraulic processes is widely recognized. No free market economy will ever protect underprivileged people from the destructive forces of water, especially in developing countries. Engineers learn through the courses to forecast and manage fluvial hydraulics risk, use the up-to-date numerical tools for the hydraulics of water courses, acquire knowledge in sediment transport and river morphology, and learn more on the know-how of flood protection measures and river training works. Biotechnical engineering methods are also presented for bank protection and riverbed stabilization. Furthermore the role of the engineer in the elaboration of concepts of river training works is discussed.

*Drinking water supply and wastewater management*

The world population necessitates the implementation of large infrastructure developments to ensure supply of water, this not only in view of its rapid increase. Before doing so the major legal and conceptual bases have to be considered. Quantitative and qualitative aspects of water supply are a vital part of every project. Therefore, before designing networks and


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optimize their functioning, the engineer, having successfully completed the course, must have an extensive knowledge of the non-technical issues of the problem. Besides the technological aspects, the following subjects are therefore taught during the course: Objectives and constraints of water resources management at local, regional and world level; priorities and competition between drinking water supply, irrigation, hydropower and other water uses; conflicts due to water; sustainable water resources management; present and future drinking water problems; drinking water quantity and quality and natural capacity of water resources. Design, construction, management and maintenance of water supply and sewer systems are treated extensively throughout the course, giving the students the required knowledge to plan, build, operate and supervise such works.

*Storage of water*
As water is unevenly distributed in space and time, it must be stored and transferred for all major uses. Water storage facilities in the world provide domestic and industrial water supply, irrigation water supply for food production, hydroelectricity, flood control, improved navigation on waterways, recreational facilities, and development of fisheries.
General layout of storage structures of all major types and sizes is taken into account in the course syllabus, as well as the planning, design and execution phases. Already existing works of all kinds have to be operated, maintained and monitored and eventually refurbished or upgraded. The safety of water storage works is also considered in the courses, it stands on three pillars which are structural safety, monitoring and emergency concept.

**Promotion of students**

In order to promote contacts after having obtained the EPFL degree in hydraulic schemes, an alumni association of former students of the Postgraduate studies in hydraulic schemes, or eventually called Association of Professionals in Hydraulic Schemes, has been established. The main goal of the association is to keep former participants of the course in contact despite the distances, represent the profession in important events and forums and enhance international partnership for development. It aims at keeping members informed of main trends in the profession as well as conveying and sponsoring continual professional formation of high technical and scientific standard at an international level. The association intends to bridge the distances between the technical and the political, economical and public worlds, by enhancing the participation of its members in the ongoing key actual discussions.

The association is currently focused on its own creation, internal organization and external presentation, having only recently started. All former participants and lecturers of the postgraduate course on hydraulic schemes can be members, as well as external candidate proposed by at least two members. Universities and state agencies can become institutional members. Regular payment of a symbolic fee will probably be due. Ongoing projects include the creation of a member database, a website, a web-based newsletter, a merit prize for current postgraduate students and the organization of regular regional meetings and events. Another indirect benefit through an alumni association is the offer of career possibilities by former students, who will hold sooner or later key positions in engineering firms. Some of the former students already showed the willingness to serve as career mentors for the new participants. It will also enhance the already existing partnership with consulting engineering companies and public administration for the student trainee program.


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Regarding the business career of former students, possible elements allowing to estimate the effective contribution of the Master course can be summarized as follows: 8 students out of ten profited from a promotion inside their company, changed company with a position of higher responsibility or created their own business. Most of the foreign students returned back in their country of origin, some even in their initial company. One postgraduate student continues with a PhD thesis at the EPFL. The effective contribution of the program regarding the professional progress of the participants is considerable. The foreign graduates are predestined to take significant design, supervisory or administrative positions in their countries, especially in the transition countries where they will be the ambassadors of the EPFL and of the Swiss economy. They will eventually promote the course to new students, keep lifelong professional personal contacts, and may even become future partners and customers for the EPFL and Swiss engineering firms.

The experience gained through mutual learning in an intercultural context during the two years course gives an additional plus to every graduate from the Master course enabling them to really take into account different cultural perspectives. The freshly graduate students will also bring in broader and fresh ideas to the hydraulic engineering business.

## Perspectives and conclusions

The course program offered is constantly updated to reflect the present and future needs in the field of hydraulic engineering. The attraction of the course is also related to the facilities offered by the organizers, and the hosting institution continues making its excellent infrastructure available for the course.
We still believe that it is of major interest to involve teachers from different worlds (higher education, industry and public organizations), thus allowing the treatment of the major complementary aspects of the chosen subjects. Besides providing the best lecturers in a chosen application field, another advantage of this kind of training for the participants lies in the opportunity to develop their professional network in a directly useful manner, as in fact the students come from the same disciplines as lecturers. And since participants benefit from a professional experience, exchanges with the teachers and class colleagues can be very stimulating. To give such an importance to the non-academic origin of the lecturer, thus ensuring a good compilation of the key competencies for hydraulic engineers, has its cost, and once again we believe that we should not only share the competencies but also the costs. This is certainly an important expenditure but it would be unrealistic and especially counter productive to make it entirely supported by only the participants.

*Explore new learning technologies*
Another way to develop the attraction of this course lies in the thinking organizers can conduct about the use of new learning technologies to flexibilize the study program. In fact foreign students could ask to realize their diploma project in their native country, even at their previous employer. In this case, contacts between students and academic supervisors at the EPFL can be facilitated by electronic means like e-mails, chat sessions or videoconferences with shared screen. Considering students who are likely to reintegrate their job after the postgraduate studies, the question of keeping in touch during the 2 years duration of the course may conduct to policies where such students could temporarily return to their company during training. Facing this kind of situations, the organizers could offer some learning content on the web allowing these students to follow the theoretical part of the program (or even the practical one) in a more autodidactic manner and on an intermediate period. But it is


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out of question that participants register for this course believing they could follow these studies entirely behind their screen at their location. Real meetings between participants in order to realize conceptual work and face-to-face exchanges with lecturers are absolutely necessary. Moreover they facilitate ulterior electronic contacts. Finally if the use of some electronic means become usual in training periods, rich, natural and easy electronic exchanges between alumni could be expected.

*Enlarge sponsoring of students*

Any forward-thinking organization knows its most important asset is its people. The same applies to educational institutions, where administration and teaching staff resides on the one hand, and on the other, in some sense as the clients, the students. They participate in the costs of their education by the payment of the tuition fee. But as we have seen before, this cannot be sufficient to cover fully the costs. Therefore, the financial contribution of the EPFL regarding course organization, teaching and management is essential in order to keep the attraction of the program, but ensuring a high-level postgraduate study program offer in hydraulic engineering is not enough. Students without sufficient financial resources should not be restricted from access, whether they come from a developing country or from Switzerland. A pretty well functioning system of scholarships exists in Switzerland for its residents and the economical situation in the hydraulic engineering business is sufficiently strong to encourage people to follow the course and being able to pay for it.

But nothing in that sense exists for foreign candidates. With the student trainee program, a limited number of places can be awarded to foreign students. But as already stated, several companies or administrations, lacking the necessary infrastructure or personal to ensure assistance for the candidates, sponsored a training place at the EPFL. We would like to enlarge this possibility over the Swiss borders for international active companies worldwide. If a student trainee is in general directly beneficial for its hosting institution by providing high ranking effort for the company, it is more difficult to see the benefits for a distant company in participating in the program. The required win-win situation should be achieved through an intelligent student sponsor program.

The organizers think of project related sponsoring of engineers participating in missions of the company. This may also apply to people related to the company in a very large sense (country, language, project, partnership, etc.). Engineering firms or contractors could even propose candidates to follow the course, as long as they are academically eligible.

While these people will follow classes at a one-day a week bases, they can continue work for their company, using the infrastructure of the EPFL and be supported by some academic supervision from local staff. This kind of student trainee will also receive a bursary that is financed by the sending or sponsoring company, which at the same time will cover tuition fees and at least partially contribute on the infrastructure and support expenses at the EPFL. As noticed before regarding the educational part, the new technologies allow this very flexible vision of work.

In one case, as a first time experience, the organizers already provided an office space for a student from Northern Italy, who continued working with its own computer equipment for his engineering consultant firm in Italy, while following classes in Lausanne. The experience was very positive, and we encourage foreign firms to promote this system among their young key engineers, who wants to enlarge their knowledge through this postgraduate course, broaden their horizon through the accompanying intercultural exchange, and also increase the companies competitiveness through newly acquired contacts worldwide.

Amongst the many benefits of the program for a company will be to obtain an employee with an EPFL Master diploma, widely recognized technical skills, high-level thinking and relevant


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career experience. As a result of the company related project period during the course, candidates will acquire other very important skills related to problem solving, critical thinking, and communication. This program will also create a sense of mutual loyalty between the company and the student, who will by the way acquire in-depth knowledge, required in engineering projects. Another benefit for the company is the saving on expensive in-house training. So by investing in their own staff development by sponsoring an employee for the two years course, the company will enhance its portfolio of key staff members.

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