

Knowledge and capacity development in the hydropower sector for developing and emerging countries

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Capacity building is the process allowing individuals, interested groups and organizations to obtain, improve, and retain skills, knowledge, tools, equipment, and other resources needed to do their jobs competently. Capacity building mobilises the capability of a society or a community to identify and understand its development issues, to act to address these and to learn from experience and accumulate knowledge for the future. The capacity building has to be supported with a so-called Knowledge and Capacity Development (KCD) system. HYPOSO is a multi-approach project to tackle several objectives; identification and mapping of the European hydropower industry, hydropower stakeholders in the HYPOSO target countries, education of new hydropower experts through capacity building activities and bringing together relevant actors from the EU hydropower sector with stakeholders in the target countries. Interaction with stakeholders is, therefore, an integral part of the activities, like workshops, capacity building activities and interviews with national/local stakeholders are envisaged in all target countries which are outside the European Union, namely workshops in Bolivia, Colombia and Ecuador in Latin America, and Cameroon and Uganda in Africa. Additionally, capacity building courses will be carried out in Bolivia and Ecuador, and in Cameroon and Uganda. Part of the project focusses on capacity building in the target countries aiming to strengthen key stakeholders in strategic development, design, implementation, operation and maintenance of sustainable hydropower and in identifying or addressing research needs in the field of hydropower. Based on the results of a previous scoping process in the target countries, the needs in education and research in the field of small hydropower have been identified. The recognized prerequisites have been integrated into a short course plan. The short course, organized as a week course in each of the target countries, includes all phases of the small hydropower life cycle; planning, design, construction, operation, maintenance, but also environmental and social impact and financing. The teaching efficiency and intensity will be increased by pre- and post-course activities. These additional activities will allow a stronger and deeper understanding of the topics and will additionally improve the quality of the capacity building. All of the activities during the course will be recorded and will be a part of a Knowledge and Capacity Development (KCD) system. The KCD system could be used by the participants, but also by additional persons interested in hydropower also after finishing of the project. Here we describe the process towards the definition and implementation of the capacity building activities; the final goal is the approximation of a knowledge ground and expertise between Europe and target countries to facilitate the cooperation between both and the development of the hydropower sector in a sustainable manner. The activities here described are an example and maybe up-scaled and further used by similar organizations aiming at the increase of capacity in the hydropower sector.

1. Knowledge and Capacity Development (KCD) tool

The 1991 Delft Declaration (Alaerts 2009) stated that “Capacity comprises well-developed institutions, their managerial systems, and their human resources, which in turn require favorable policy environments, to make the water sector effective and sustainable”. Knowledge and Capacity Development (KCD) is necessary at the levels of the individual, groups and organisations to strengthen technical, financial, and managerial skills. (Alaerts, 2009). It will change the process of work and will improve governance with an effective decision-making process,

accountability and transparency under proper educational formats and training. The Delft declaration was recently revisited by the 2020 Delft Agenda for Action on Knowledge and Capacity for the Water Sector, ensuing from the 6th International Symposium on Knowledge and Capacity for the Water Sector. The Agenda insists that successful capacity development initiatives need to be more systemic. It refers also the need to, together with an increase of the technical proficiency of individuals, operate changes in the political and social changes in institutions for the improvement of services delivery in the water sector. Implementation of KCD tools in the hydropower sector will help transfer the European technical knowledge for institutional development and change and to learn together and build a common understanding of the necessary changes.

The World Federation of Engineering organizations (WFEO, 2010) suggested six essential “pillars of engineering knowledge” that must always be in place and balance. The pillars are considered as necessary for sustainability in engineering infrastructure and services. Appropriate, effective and sustainable methods mobilize sufficient and stable technical and decision-making capacity to deliver services for engineering infrastructure. The pillars, which are transversal across several knowledge disciplines, are Individual; Institutional; Technical; Decision-making; Finance and funding; Resources, equipment, tools and supplies.

The value chain for networks for capacity as described in Bloom et al. (2009), clearly shows how interconnectivity and development contribute to a larger capacity. As capacity can be defined as “the capability of a society or a community to identify and understand its development issues, to act to address these and to learn from experience and accumulate knowledge for the future” (Alaerts & Kasperma, 2009), a KCD project should not only focus on obtaining knowledge, but rather sharing this knowledge with peers, experts and policymakers to implement changes for aforementioned issues. Strong cooperation between individuals and the organizations and institutions where they work ensures an enhanced capacity. Therefore, there are five main objectives of capacity building: to connect experts, professionals and policymakers to share their knowledge and discuss development issues; to generate innovative ideas; to explore and make choices regarding the implementation of these innovative ideas; to implement the innovation and embed it in organizations and institutions; to actively share innovations amongst each other.

In the HYPOSO project, the goal of the capacity building activities is to strengthen key stakeholders in target countries in strategic development, design, implementation, operation and maintenance of sustainable hydropower, and in identifying and addressing research needs in the field of hydropower. Developing countries, as the HYPOSO partner countries in Africa and South America, often lack experienced personnel and have frequent changes in staff members, resulting in loss of knowledge and experience. For capacity development and mitigating consequences of staff fluctuations, a Knowledge and Capacity Development (KCD) tool will be implemented which consists of the following research lines:

- Measuring existing capacity and foreseeing future capacity and research needs.
- Analysing the dynamics of dissemination of professional knowledge and allowing access to the global knowledge pool in education, in rolling out sector programs through national and local government levels and in hydropower operator partnerships.
- Improving the use of knowledge: knowledge management for the public sector.
- Assessing (measuring) and transmitting through the adequate communication channels the economic and social value of KCD.
- Understanding the determinants of KCD effectiveness by quantitative assessment of the added-value of knowledge.
- Analysing the dynamics of the learning, competence building and innovation system for the hydropower sector.

The scope of the HYPOSO project is to develop and implement procedures and tools to improve systematic learning at all levels, i.e. individuals, groups/teams and whole companies. The groups approached by the project should include consultants, engineers, technicians, governmental and financing bodies and all other stakeholders. The KCD system must provide a measure of the added-value brought by highly trained cadres, which should be the basis for faster and more effective planning and efficient and straightforward permit process and will give the basis for the planning of future KCD activities. Capacity building emphasizes the following topics:

- strengthening project preparation capacities,
- reinforcing project design and project implementation,
- improving ESIA (Environmental and Social Impact Assessment) compliance,
- strengthening of operation and maintenance,
- researching the specific and target country-oriented topics.

Capacity building has to be a life learning process, and the KCD is conceived to follow this perspective. Long-term objectives, beyond the project duration, will provide participants with a continuous opportunity for learning and deepening their knowledge in the field of hydropower. Additionally, the KCD will be conceived in such a way that new participants, from partner countries and also other developing countries, could access the system and get information and improve their knowledge in the field of hydropower and European hydropower information. These long term objectives are summarized as follows:

- Formation of the knowledge system on important subjects and for all phases in the hydropower life cycle; planning, design, construction, operation and maintenance.
- Formation of the tools and methods to continuously train the staff and to introduce and train new staff members.
- Formation of the research basis for continuous improvement of the specific hydropower needs.

For the implementation of the project and the long term objectives these specific objectives have been defined:

- to develop a pool of professionals for sustainable hydropower, who will be able to manage and actively support the planning, design, construction, operation and maintenance of hydropower projects,
- to strengthen hydropower capacity based on problem-solving multidisciplinary project development and training on-demand,
- to develop a knowledge base and to build human and institutional capacity through the process of knowledge sharing, creation, dissemination, and application of challenging hydropower themes between all personnel involved in hydropower,
- to develop a sound monitoring and facilitation mechanism to guide and support the development of new company hydropower staff.

The training of hydropower professionals will be prepared as on-the-job, mobilizing water education networks, promoting joint research, giving policy advice, supporting distance & e-learning, facilitating participation in innovative projects and facilitating knowledge sharing. Thus, HYPOSO plans to prepare a new generation of hydropower experts who will enhance sustainable energy production with the help of European hydropower know-how and equipment.

2. KCD in hydropower

2.1 Concept

From the phase of project identification over the design until construction, operation and commissioning of the components, hydropower projects should be economically, technically, socially and environmentally feasible. In any hydropower project, KCD is important to achieve these criteria incorporating sustainable goals. Every stakeholder involved in hydropower should participate in the process of KCD.

The KCD system must provide a measure of the added-value brought by highly trained cadres. This should be the basis for faster and more effective planning and efficient and straightforward permitting process supporting and strengthen the planning of future KCD activities.

In this particular case, the blended approach chosen for training is supported by the use of a Moodle platform for online learning in this project. Moodle is a learning platform that provides educators, administrators and learners with a single robust, secure and integrated system to create personalised learning environments. Moodle has been

used at IHE Delft for several years for all types of education; MSc. and PhD programs, short courses, training on-demand and online courses. Online learning can enhance face-to-face learning and vice-versa, especially when both are interconnected.

Online learning is focused mainly on cognitive skills (thinking) rather than affective and psycho-motoric skills, which are best learned in a face to face setting. Therefore, we will set up an online component in the participant's preparation strongly focused on knowledge. An advantage of the preparation of knowledge clips is that these can be used multiple times. During the training days, lecturers and participants can then focus more on practical applications.

During the training, the Moodle platform can act as a repository for training materials, and as a virtual meeting space where participants and others may interact with each other in forums and web conferencing. Online interactivity is essential when participants are asked to share from their own experience and can be done in words (forum, chat) and video (a vlog, or a video conference). When participants are immersed in a good online social environment, they tend to return faster to an online course and retain more knowledge from it.

2.2 Methodologies

To fulfill the objective of capacity building and achieve the target of training, it is essential to choose an appropriate training method. We opted by the methods of Voith Hydroschool which introduced the Systematic Approach Training (SAT) in five phases (Henkes, 2019). Firstly, a gap analysis was done to identify the learning demand of trainees. Second, during the design phase, the selection of the training and teaching method with location and date is fixed based on the analysis done in the first phase. Third, in the development phase, the training content is prepared. Fourth, the content is implemented by the instructor to convey knowledge with different training activities. Finally, in the fifth phase, the evaluation of overall training and training effectiveness determination is performed.

Additional to Voith Hydroschool's systematic approach, knowledge from other capacity development researchers will be integrated and an iterative component implemented (Morrison et al. 2013). The iterative component means that after evaluation of the processes the course is updated with the knowledge earned through evaluations and a new improved version of the training is prepared. This method will be used in the project when the knowledge and data collected during preparation and executing the training in Africa will be used for improvements in the training in South America (see section 4 for a more detailed description of activities).

2.3 Learning and teaching activities

Learning is an active process that requests activation from teachers and it requests from participants to invest actively in the process. The connection between 'theory' and 'practice', as proposed via the prototype projects, is very effectively supporting the active learning process. The training approach will ensure the specialized knowledge to be understood as well as the overall understanding in the context of entire projects.

All training and teaching sessions will consist of a mix of lecturing and active learning activities, making learning an interesting experience. Depending on the competency framework and its components, the more skill-based competencies will be delivered as practical exercises, while the information-based parts will include individual and/or group exercises or tasks.

An interesting line is to build up connections with one or a few top universities in the target countries active in hydropower education or teaching topics that are important for hydropower development. Collaboration with these universities can bring benefits for both sides in innovating and updating their knowledge and expertise, but also in cooperative research work between European universities and the universities in the target countries. The universities in target countries will be a place for recruiting of the new specialist in a later stage and will be collaborators for answering the research questions.

HYPOSO strives to deliver an "impact-based training program", i.e. 'the training shall enable people to perform'. This means that the training needs to be related to the job(s), leading to improved performance on the job. The effect of continuous learning and life learning will be achieved by creating of the Knowledge and Capacity Development (KCD) platform. The platform will be organised by IHE Delft and will include all lecturing material prepared during

and for the course. The participants, visitors and also further interested persons will be allowed to log in on the platform and refresh or learn additional topics and, in that way, engage in a continuous learning process.

3. Results of the scoping in the target countries

Based on scoping the current status of the hydropower sector in the targeted countries, there is a huge potential for the construction of new powerplants and there is also the need for optimization, maintenance and refurbishment of the existing powerplants. Hydropower research and development in the African countries is lagging behind in comparison to the South American countries. Overview of the existing high educational system on hydropower shows that though skilled manpower is produced in the target countries, but the current education system does not give a possibility for the production of hydropower experts. Hydropower personal is normally educated and trained during the work. Also, no target country has a master's program in hydropower development. Defining and organising hydropower research and development, under such conditions is not easy and not effective, therefore more skilled persons are needed.

Another big problem in developing countries is a large fluctuation of skilled manpower. The main reasons for the strong fluctuation of site personal are that the person trained during the work especially in operation and maintenance of the powerplants are desired persons for other industries and are often headhunted. Also, higher salaries and more attractive working places are found in the municipalities and towns than at the hydropower plants situated mostly remote areas.

The short course will allow participants to learn more and deeper about hydropower, giving them an overview of the whole life cycle process. Data collection, hydraulic and structural design, construction, operation, maintenance and refurbishment issues will be covered, together with important topics such as environmental and social impacts and financial possibilities.

Knowledge and Capacity Development (KCD) will be prepared, giving participants support during and after the course. Also, KCD will be used by persons participating on the course and by other persons interested in learning about hydropower and/or broadening of their hydropower knowledge. KCD will be used as a platform for knowledge exchange and recruiting of the new hydropower personal.

4. Training/Teaching Method

4.1 Study plan

The short course is specified with two weeks lecturing. Intensification of the teaching quantity and quality will be enriched by activities before and after the course lecturing. The overall teaching/training method, therefore, consists of virtual class before the course, face-to-face course during the actual course and virtual class after the course (see Table 1). The face-to-face courses are planned as eight days in each of the target countries, Cameroon, Uganda, Bolivia and Ecuador.

	Topic	Responsibility	Days		
			Online	Face-to-face	Online
			Preparation before course	Short course	Assignments after course
Week 1	Basics of hydropower exploitation	IHE	0.5	0,5	
	Hydrology	IHE	0.5	1	1
	GIS & HP potential	VDU	1	0.75	1
	Hydraulic design	IHE	1	1	1
	Computer based tools for hydropower resources	VDU	1	0.75	1
	Dams and storage basin	IHE	1	1	1
	Weirs and water intakes	SF	0.5	0.5	0.5
	Power waterways	IHE	1	0.5	1
	Total week 1		6.5	6.0	6.5
Week 2	Hydraulic Units	IMP	0.5	1	1.0
	Electrical equipment & lines	IMP		0,5	0.5
	Hydropower systems	SF IHE	1	1 0.5	1.5 0.5
	Operation and maintenance	IMP/TRMEW/SF		1	1
	Financial analysis	1to3			1
	Design training	SF		1	3
	Total week 2		2.5	6	9.5
Total study load (week 1 + week 2)			9	12	16

Table 1. Teaching plan for the hydropower short course

The first online section aims to introduce the topics and explain hydropower basics such as; function, types, operation of hydropower; also, it will give a comprehensive overview of the subject matter. This part of the virtual class consists of a set of video lectures performed by lectures explaining the topic. It is combined with other educational materials such as publications, reading material, videos, etc. Assignments (quiz and group work) will be incorporated into the lectures.

The face-to-face part will be a system of lectures and discussions that will be performed in the target countries. These lectures will go more into the topic's details, explaining the specific parts of the topics, design and calculation methods, examples for practical use. The education material will be presented in more detail to describe the subject and making it clearer to the participants. Discussions during the lecturing will help clarify doubts and answer questions from the participants. During this part, the understanding of the participants will be evaluated too.

In the third part, there will be an online class after the course with additional assignments (individual or group). In case that during the face-to-face course topics will be detected that are of participant(s) interest and not adequately treated during the course, these detected topics will be extra prepared for the third part of the short course.

During the third online phase after the final (second) week, the work on the selected feasibility study is planned for the participants. In this work, the participants will implement the knowledge collected during the short course and will present their knowledge and skills. In the third online section, discussions and meeting (evaluation) with the participants is foreseen. This is important to get a participant's feedback and improve the lecturing for future courses.

4.2 Study Tours

During each week of the course, a two-day study tour will be organized. The study tours aim to visit several hydropower systems. With an organized study tour to the hydropower plant, the teaching material presented during the course will be seen in the praxis and the applications will be discussed. The site tours will be organized and guided by the local project partners. The lecturers that will participate in the site visit will use the site visit for a better understanding of the learning objectives. The COVID-19 restrictions caused the rescheduling of the short courses and also restrict possibilities for detailed side trip planning. The preliminary sites for the visits are :

Bolivia: the site trip is planned as a two day trip from the short course venue in Cochabamba and it includes visits to the HPP Corani Power House and HPP San Jose II.

Cameroon: the training will be organized in Ebolowa and the trips will be organized to Memve'ele power plant (211 MW), or Mekin (15 MW) power plant.

Ecuador: the course will be held in Quito and two hydropower plants are planned for the visit located in the Tungurahua province: Rio Verde Chico (10 MW) and the large hydropower plant Agoyan (156 MW), the third most important hydropower plant of Ecuador.

Uganda: the training venue will be in Kampala and the proposed field visits are to Nalubaale (200 MW), Uganda's oldest power dam (formerly Owen Falls dam), near the source of the Nile, and then to Isimba (183 MW) HPP, Uganda's latest addition.

4.3 Organization

The short course will take place in the target countries in Africa, in Cameroon and Uganda and South America, in Bolivia and Ecuador. In each country, a 6-day short course following by two days site visit is planned. The total course time is limited to eight days in each of the training countries. The short course is planned as a face-to-face event with all lecturers actively presented in the country and lecturing venue. The participants on each course are coming from both countries of the continent.

Considering eight participants from each country it is planned to have 16 regular participants. The course will be open for other interested persons that could take their costs. No fee will be set for the other participants. Based on the number of the other participants and their participation in the out-course activities (lunch, dinner, visits, etc.) they could be asked for the refund of the cost. These off-regular participants of additional university staff teaching hydropower topics and governmental organisations (decision-makers) are especially welcomed and will be additionally motivated to participate.

4.4 Selection of participants

The participants should be recruited from all groups of the stakeholders involved in a small hydropower process (design, legalization, construction, operation and maintenance). Therefore the consultants, engineers, technicians, governmental and financing bodies and also the environmental staff. Based on the given study plan and existing project budget, on each continental short course, approximately 8-10 participants from each country will take part. For these participants, the whole costs (travel, accommodation and meals) will be sponsored by the project. Additional participants that could sponsor their travel and stay are welcome.

Based on the discussion with the target countries the participants will be from these main stakeholders:

- National and local government (ministry of energy, water, environment or planning, a local governmental sector in administration and regulation of natural resources),
- National electricity company and private hydropower energy operators.
- Academy (staff teaching and researching in hydropower).
- NGO's working in hydropower.
- Hydropower investors.

The selection of the short course participants will be coordinated by the target countries. Potential participants will receive a letter of invitation addressed to their institutions, and will be selected based in the following requirements: work experience in the hydropower sector, background in electrical/civil/environmental/mechanical engineering, and their English skills, an intermediate level will be needed.

4.5 Schedule

The courses have been planned firstly in Africa and then in South America. The courses should start in September 2020 in Uganda following in February 2021 in Cameroon. Because of the COVID-19 restrictions, the September course in Uganda has been postponed. The alternative has been found in April 2021 in combination with AFRICA 2021 (<https://www.hydropower-dams.com/africa-2021/>). The conference AFRICA 2021 will be held on Lake Victoria, Uganda from 13-15 April 2021. The HYPOSO project team is planning a session on the conference presenting the project and the outcomes. Therefore the course will be combined with this conference event. The courses in South America are planned in November 2021 in Bolivia and in December 2021 in Ecuador. These courses are also planned before the end of the HYPOSO activities in South America in December 2021.

We are planning the courses as face-to-face events. In case that COVID-19 restriction will be still valid in 2021 the alternative to hold the short course fully online could be discussed. Such a solution has the main disadvantage in missing the personal contact between teachers and participants and is therefore considered just as the last possible option.

5 Concluding remarks

HYPOSO is European Union's Horizon 2020 project supporting the EU industry to foster more clean and reliable energy in target countries in Africa (Cameroon and Uganda) and Latin America (Bolivia, Columbia and Ecuador). Thirteen project partners from Europe, Africa and Latin America work together to achieve the objectives in the promotion of the European hydropower industry, improve the status of hydropower and increase the share of renewable energy in the target countries.

Capacity building will strengthen key stakeholders in strategic development, design, implementation, operation and maintenance of sustainable hydropower and in identifying or addressing research needs in the field of hydropower in the target countries. Capacity building is the process allowing individuals, interested groups and organizations to obtain, improve, and retain the skills, knowledge, tools, equipment, and other resources needed to do their jobs competently. Capacity building mobilises the capability of a society or a community to identify and understand its development issues, to act to address these and to learn from experience and accumulate knowledge for the future. The capacity building has to be supported by the Knowledge and Capacity Development (KCD) system. The KCD system developed during the project will be a key bone of the further life learning process where the participants but also additional applicants from the target countries and other developing countries will be able to deepen and widen their hydropower knowledge and preparing a new generation of hydropower experts enhancing sustainable energy production.

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