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World Small Hydropower Development Report 2022

THEMATIC PUBLICATION:

PROSPECTS FOR YOUTH IN THE SMALL HYDROPOWER SECTOR

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Table of contents

Introduction

The global youth population continues to grow and the number of people aged between 15 and 24 is expected to reach 1.3 billion by 2050, with Africa predicted to see the greatest increase.[1] This population growth trend, however, is overshadowed by high levels of youth unemployment, which is especially noticeable when compared to the adult population. Specifically, young people are three times as likely as adults (25 years and older) to be unemployed.[2] If left unaddressed, this issue might slow down social development and cause social unrest, especially in developing countries where the ratio of youth is significantly higher.

Efforts aimed at employing young people, as well as ensuring their overall well-being, can be hindered by the lack of access to reliable sources of energy. At the same time, the climate emergency and ubiquitous environmental collapse dictate the necessity and urgency to focus not only on developing the energy system but also on ensuring its sustainability. The development of the renewable energy sector can provide an avenue for achieving the goals of youth employment and development while addressing energy-related challenges. Young people around the world can play a key role in creating the change required for the transformation of the global energy system, thus, contributing to regional and international development aims, including the United Nations Sustainable Development Goals (SDGs), while at the same time finding and creating opportunities for their own professional and personal development.

Small hydropower (SHP) is one of the renewable energy technologies that have the potential to play a significant role in both reducing reliance on fossil fuels in developed and developing countries and assisting the communities whose development is currently hampered by insufficient electricity supplies. Given their compact size (usually up to 10 MW), SHP plants are much quicker to construct and also tend to have low capital investment and operational and maintenance costs.[3] SHP projects also carry positive social benefits as they usually encourage community participation and capitalize on local skills for design, construction, management and operation.[4]

According to the *World Small Hydropower Development Report (WSHPDR) 2022*, much of the world's SHP potential remains untapped (59 per cent of the known potential), primarily in Africa, South-Eastern Asia, Eastern Europe and Latin America.[5] This undeveloped potential offers great opportunities for young professionals and entrepreneurs to get involved in providing clean energy to communities in those regions and beyond. The active participation of youth in SHP can play a vital role in achieving a sustainable energy system because young people can bring the creative and forward-oriented thinking that is needed for a rapid energy transition. However, young people continue to face multiple barriers in accessing the required skills as they often do not receive the policy, institutional and financial support that could help them get involved in the SHP sector.

This publication is a result of a collaboration between the United Nations Industrial Development Organization (UNIDO), the International Center on Small Hydro Power (ICSHP) and the SDG7 Youth Constituency to highlight the prospects for youth involvement in the SHP sector. So far, very few studies have looked at the role of young people in SHP, including the factors that can encourage youth involvement in the sector as well as the opportunities it offers to young professionals. To address this gap, this publication explores different opportunities that exist for youth in the SHP sector, with examples of projects around the world. The report also analyzes the main barriers that young professionals considering joining or transitioning to this sector face as well as the existing challenges faced by young energy professionals, including young women, already involved in the SHP sector. The report also provides a list of recommendations on how to overcome the existing barriers. Finally, potential career paths for young people in the SHP sector and an overview of one youth-led SHP project (Blupower in India) are highlighted.

The goal of the publication is to highlight the benefits that SHP brings to youth, communities and industries worldwide and explore how young people can bring new ideas and innovation to the sector. Given the very limited availability of information on the topic of youth involvement in the SHP sector, the analysis could not be informed by literature review alone. Consequently, this report is based on the first-hand experience of a group of experts involved in the SHP sector and their knowledge of the related opportunities and challenges existing for young people in the sector.

In developing this publication, a total of 21 experts involved in the SHP sector in Africa, Asia, Europe and the Americas were interviewed. The contributing experts were selected from the ICSHP database of international partners or were identified through independent online research. To ensure fair representation, gender, region of operation, as well as experience in the SHP sector, were considered when selecting the experts. Of the total of 21 interviewed experts, 8 were female. A list of contributing experts is provided below. Based on the preference of each expert, either a live virtual interview was conducted or written responses to the interview questions were collected via email.

It should be noted that, while information on more of the existing SHP projects developed and managed by young people would make an invaluable contribution to the present analysis, identifying such projects proved to be an unexpectedly difficult task. Taking into account this limitation as well as the overall shortage of information on the topic, this publication should be seen as the first attempt to collect in one place the experiences related to youth involvement in the SHP sector across countries and regions and will, hopefully, encourage further efforts on both the international and local levels to better understand the topic.

List of contributing experts

	Name of Expert Interviewed	Organization Name	Category/Role	Location
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19	Emanuele Quaranta	European Commission	Researcher	Italy
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21	Fujimoto Tokihiko	Shizuoka University, National University Corporation	Associate Professor	Japan

I. The potential of SHP for youth employment

SHP has great potential for job creation for young people, both directly and indirectly. Direct employment opportunities in the SHP sector include, for example, jobs in project design and permitting, turbine manufacturing, management and engineering of project development, construction, etc.[6] According to the International Renewable Energy Agency (IRENA), the off-grid value chain alone, including sales, marketing, installation and services, could create at least 4.5 million jobs for young people globally by 2030. Hydropower has the largest installed capacity of all renewable energy technologies in the world, with the sector employing 2.1 million people directly, three quarters of whom are in operations and maintenance.[7]

Well-structured SHP projects can offer competitive salaries, technical training opportunities for young people both in their own countries and abroad as well as opportunities for the development of multiple skills, such as technical, administrative, managerial and commercial skills. Within companies engaged in SHP projects, employees can have the opportunity to move from one department to another thus expanding their skills in several professional fields.

> "An SHP project employs on average 18 people, but this number is smaller in other renewable energy sector projects of the same scale". (Prof. Arun Kumar; AHEC, Roorkee, India).

In their turn, young people can bring to their roles in the SHP sector characteristics and skills such as enthusiasm for social and technological change, openness to new ideas and solutions, innovative thinking, flexibility, the ability to be trained and retrained easily and the ability to adopt new technologies more easily. These qualities make young professionals valuable contributors to the sector and can be particularly critical for keeping the sector in line with the requirements of the global energy transition challenge.

Some country-specific examples below illustrate how SHP development directly contributes to the creation of job opportunities for young professionals:

- In Rwanda, a 445 kW run-of-river (RoR) containerized SHP plant was installed on the Rubagabaga River to generate clean electricity for both the local community and the national grid. During the construction of the plant, more than 1,500 local people were directly employed, over half of whom were young people.
- The 2019 report of the Brazilian Association of SHP (ABRAPCH) states that the SHP plants under construction or awaiting the start of construction in the country can create over 100,000 jobs. ABRAPCH also estimates that the country's SHP potential, if exploited, can create more than 1 million jobs in the near future and many young people can be employed in the sector.
- In China, there are approximately 45,000 SHP plants. In total, they employ more than 580,000 workers, including approximately 180,000 technicians.
- In Austria, approximately 2,850 SHP plants are connected to the national grid with a further 2,000 SHP plants used for on-site consumption off the grid.[8] The entire hydropower sector generated 4,600 full-time equivalent (FTE) direct and indirect jobs in the country in 2017, offering opportunities for young people to be employed in the sector.[9]

As the energy transition accelerates, it is expected that the automation level of SHP will increase, allowing plants to perform unattended operations, centralized dispatching and patrol maintenance. Automatization and digitalization of SHP also create new employment opportunities for young people, particularly, in software development and data analysis.

The deployment of SHP plants also leads to the creation of indirect job opportunities, which further accelerates the development of rural communities. For instance, in Malakand in Pakistan, SHP helped local businesses of bakers, tailors and flour millers to expand and meet the local market demand. At the same time, new business opportunities were created.[5] For example, local companies can now dry fruits such as red persimmon using electric driers to produce a better-quality product with higher market demand. By increasing local fiscal revenue and promoting economic development across multiple sectors including local industry, agriculture, commerce and trade, electricity access through SHP also helps create new jobs, including for young people. Some examples of indirect job opportunities created as a result of the development of SHP plants are listed below:

- In Uganda, the only source of electricity at the Kisiizi hospital is a 60 kW SHP plant.[10] Due to the reliable power supply from the installed SHP plant, the hospital has a workforce of 300 staff including seven doctors and 100 nurses.[11]
- The *WSHPDR 2019* Case Studies section presented that in the Xingshan County of China 84 SHP plants were built with

a total installed capacity of 220 MW. Mining enterprises in the county, accelerated by SHP projects, have an annual mining capacity of over 2 million tons and have created more than 1,000 jobs. Since 2011, Xingshan County has also established an industrial park in Pingyikou and attracted several new industries with high technology content, good economic returns, low resource consumption and low environmental impact. As of 2019, eight enterprises had settled in the park, providing over 600 jobs.[5]

II. Existing incentives for youth participation in the SHP sector

Renewable energy is the fastest growing energy source, but for renewable energy technologies to be competitive against fossil fuel-based energy, governments need to put in place incentives to support renewable energy industries, including SHP.[12] Likewise, the involvement of young people in the renewable energy sector can be supported by various government incentives as well as by private sector initiatives. Examples of existing incentives that can support young people joining the SHP sector include the following:

- In Honduras, since 2016, universities have been offering a renewable energy engineering degree. There are also diploma programmes (three-month training courses), apprenticeships and scholarships available.
- In Tanzania, in 2018 the East African Centre of Excellence for Renewable Energy and Efficiency (EACREEE) in collaboration with UNIDO, the International Centre for Hydropower (ICH) and the University of Dar es Salaam (College of Engineering and Technology) opened the East African Regional Training Centre on Operation and Maintenance of Small Hydro Power Plants. The overall objective of the workshop centre is to provide SHP-related technical training to East-African youth to increase access to electricity in the region and ensure there is a pool of young professionals able to carry out the operation and maintenance of SHP projects.
- The Federal University of Technology, Akure (FUTA), Nigeria, offers a training programme aimed at building technical capacity in rural and SHP systems in Western Africa. The training programme was developed through a partnership between the FUTA Centre for Renewable Energy Technology (CRET) and a team of international experts from ECREEE, GIZ (German Agency for International Cooperation) and the Nigerian Energy Support Group.
- In the Dominican Republic, the Government alongside other stakeholders involved in the SHP sector developed specific policies aiming to incentivize the participation of young people in SHP projects, including incentives for youth employment in SHP companies and other employment sectors in the country. For example, the Dominican Network for the Sustainable Development of Renewable Energy (REDSER) together with the Small Grants Programme of the Dominican Republic (SGP DR) and *Guakía Ambiente* is working with the Ministry of Energy and Mines to support a group of young technicians within REDSER. The objective of this collaboration is to strengthen the role of these young SHP technicians and ultimately ensure the greater sustainability of community micro-hydropower plants. The lines of action include building more specialized technical capacity and promoting more stable working positions. More concrete action is still required to implement these policies to make the participation of young people in SHP projects more effective.
- In Indonesia, SHP companies offer internships for young professionals twice a year, with the possibility of full-time employment in the sector.
- The Government of the Philippines is working on a green education programme to encourage the interest of young people in hydrology, hydropower in general and SHP specifically, and to offer formal training to further young people's careers in these sectors.
- In India, there are plans to institute vocational training in 2022, along with technician-level courses in communities with existing SHP plants to encourage the participation of young professionals from those communities in the SHP sector. For career development in the SHP sector, there are degrees and short-term training programmes organized by the Department of Hydro and Renewable Energy of the Indian Institute of Technology in Roorkee.
- In the United States, there are several Government–sponsored events (such as conferences) and scholarships that assist with networking and linking companies to young professionals seeking jobs in the SHP sector. For example, the Hydropower Research Foundation hosts career fairs that are held at least once per year and bring together job seekers that are currently in university and are looking for employment in the SHP industry upon completion.
- In Canada, some universities have incorporated SHP into their energy-related training programmes. For example, the University of Toronto is preparing an MEng programme in hydropower development and redevelopment. Some universities in Quebec have programmes in hydropower as well.

- The Hydro Empowerment Network (HPNET) is a knowledge exchange and advocacy platform aiming to advance hydropower with up to 1 MW in marginalized regions of the Asia-Pacific region, Latin America and Sub-Saharan Africa. The network offers a range of training opportunities and learning tools, including the E-Learning Platform for Social Enterprise for Energy, Ecological and Economic Development (SEEED), a portal on productive use of micro-hydropower and an interactive library.
- UNIDO, as a leading organization of the UN system in the SHP sector, invites young people on an ad-hoc basis to participate in project preparation and implementation, which is recognized as on-the-job training.
- Training is an activity that ICSHP has always attached great importance to since its establishment. With the support of the Government of China and UNIDO, ICSHP has provided SHP-related technical training to more than 1,000 professionals from more than 80 countries. The training methods are on-site and offline. In 2020 and 2021, ICSHP carried out online training and opened the Small Hydropower Cloud Forum, an online platform inviting experts to make presentations and lectures on SHP (currently in Chinese). At the moment of the writing of this report, 28 sessions had been held as part of the Forum, with a total of more than 3,000 participants. Furthermore, ICSHP has organized a team of SHP experts, a technical exchange group and the Hydropower for Today Forum, using a combination of virtual and hybrid presentations.

Young people who want to start a business in the SHP sector or join SHP companies, frequently lack knowledge of the various policy and financial incentives (e.g., subsidies and tax incentives) available in the sector, as well as of networks that can provide information on where to access funds for start-ups. Knowing about such schemes is key to accessing external funding for SHP projects. On the other hand, the optimal design of incentives aimed at individuals, businesses and local governments, which also accounts for the externalities associated with the development of SHP projects, is critical for the successful integration of young people into the sector. Thus, adequate policies that provide financial and other incentives and regulatory streamlining efforts can pave the way for encouraging youth participation in the SHP sector.

Examples of incentives available for the SHP sector include the following:

- In Japan, the Government supports the development of SHP projects by giving a high feed-in tariff (FIT) of 34 yen per kWh (0.32 USD/kWh) for installations below 200 kW, which enables a faster payback.[13] The FITs and other benefits encourage the communities and other stakeholders, including young people from urban areas, to establish community-owned SHP businesses in their hometowns.
- In Indonesia, young professionals interested in starting an SHP project can easily enter into an agreement with a community that has the potential for an SHP plant and obtain funds for construction from community members. However, if the plant generates 10 MW of power or more, a required permit from the Government must be obtained.
- The European Commission funds several projects aimed at raising awareness in the hydropower sector, including XFLEX HYDRO and Fish Friendly Innovative Technologies (FIThydro).[14] XFLEX HYDRO is a four-year project aimed at showcasing how modern hydropower plants (including SHP) can provide the vital power grid flexibility services required by any country investing in variable renewable energy. The project demonstrates new hydropower technologies such as smart controls, enhanced variable and fixed-speed turbine systems, as well as a battery-turbine hybrid. The work will conclude in 2023 by delivering a roadmap to increase the adoption of these solutions across the European hydropower fleet and prepare impact assessments outlining the market and policy challenges for governments, regulators and industry. FIThydro is a four-year EU research and innovation project (funded under H2020) which aims to support decisions on the commissioning and operation of hydropower plants (including SHP plants) by use of existing and innovative technologies.

III. Professional networks available for young people in the SHP sector

Young people are uniquely positioned to benefit from professional network membership in significant ways, as it can offer opportunities for connection, collaboration, visibility and community outreach. Joining a professional organization is essential for staying up-to-date on the latest knowledge, practices and opportunities on a local, regional and global scale. If professional associations create content that gives young people a strong professional foundation, this not only helps them in their careers but also creates more knowledgeable members for the organization. However, recent research from the Naylor Association Communications Benchmarking Survey suggests that in Northern America, more than half (56 per cent) of professional associations admit they have trouble engaging young professionals and 55 per cent of associations have trouble customizing their communications for different member subgroups.[15] This disconnect can be overcome if professional associations better understand the motivations of young people and are willing to create targeted marketing campaigns.

There is little documentation of the importance of professional networks for young people in the SHP sector. One interesting example is the Brighter Khuzama project, a first-of-its-kind initiative by the Khuzama Students' Care Union in Nagaland, India, which led to the installation of a 550 W mini-hydropower plant that lights up 31 street lights in Khuzama village. The members of the union participated actively in this project either on the main installation works or in support activities such as preparing food for the team. The project was a success because of the cooperation and contribution of all members of the union.[16] The example of SHP development by the Khuzama Students' Care Union shows that professional associations increase collaboration and skill development, suggesting that young people in the SHP sector are likely to greatly benefit from belonging to associations.

The SHP sector has numerous professional associations and training programmes at international, regional and national levels which young people can leverage on. Some examples of these are shown in the table below.

Professional networks available for young people in the SHP sector

Location	Available Professional Networks
International	· The Global Network of Regional Sustainable Energy Centres (GN-SEC), which includes seven renewable energy and energy efficiency centres.[17] · In 2021, young employees at the International Hydropower Association (IHA) created a young people's network called the Young Professionals in Hydropower following the recommendations from the Youth in Hydropower event held during the World Hydropower Congress in 2021.[18]
Regional	· Regional Centre for SHP in Asia and the Pacific (Hangzhou Regional Centre [Asia-Pacific] for Small Hydropower [HRC]).[19] · The Hydro Empowerment Network (HPNET) for young professionals in the Global South.[20]
Indonesia	The Indonesian National Committee on Large Dams (INACOLD), the Indonesian Association of Hydraulic Engineers (HATHI) and the International Commission on Irrigation and Drainage (ICID) offer networking and training opportunities in the sector. The existing associations are for young professionals to network and gain exposure in the sector, but they are mostly for university graduates (and include specialized youth groups) to acquire knowledge and understanding of existing project operations and to access networking and mentoring opportunities with senior associates.[21]
Japan	Professional networks for the development of SHP projects exist, such as the Japanese Agricultural Cooperatives. The cooperatives' activities were formerly centred on water for agricultural use, but recently their objectives changed to the usage of water for power generation.
Italy	Within the International Association for Hydro-Environment Engineering and Research (IAHR), which is typically academic, there is a section for a young professional network (for people under 35 years of age), which usually holds annual conferences for young professionals to meet and network.[22] Equally, there is an Italian Association of SHP, whose function is to provide support to companies, for example, with an understanding of the tariff structure.

Dominican Republic	The Dominican Network for the Sustainable Development of Renewable Energies (REDSER) is a nationally recognized network that all micro-hydropower plants/communities joined 10 years ago. In this network, there is a special focus on youth, with young people getting involved in capacity building related to the technical issues of SHP projects.[23]
USA	The Future Leaders of Hydropower (FLOW) offers networking events, specifically virtual meetups where individuals can talk about their work in hydropower.[24]
Canada	The Ontario Waterpower Association's Leaders of Tomorrow Summit is an annual summit that brings together young people in the hydropower sector to share experiences, perspectives, insight and advice about the past, present and future of the hydropower industry in the Province of Ontario to identify human resources, educational challenges and opportunities that the sector is facing.

Sometimes, membership fees can be a barrier to youth participation in professional networks, but capitalizing on the skill-sets of young professional members can help combat this. Peer-to-peer learning opportunities, when two or more students (or co-workers) teach each other, can help lower costs and generate interest in participation.

IV. The potential for youth entrepreneurship in the SHP sector

Young entrepreneurs have the potential to contribute to the innovation needed to drive long-term social development at the local, national and global levels. This requires bringing young people into the development of projects and policymaking processes as legitimate stakeholders. Some young entrepreneurs who are already creating this change in their local communities through SHP include:

- Nicholas Berner and Nicholas Cabral, founders of the Goose River Hydro company, are two young SHP entrepreneurs who in 2017 rehabilitated worn-out dams on the Goose River in the State of Maine in the USA and transformed them into SHP plants with a capacity of 33–48 kW. The new plants serve the local community while selling excess electricity to utility companies.[25]
- Magiro Power is a youth-led SHP company in Kenya that has three SHP plants with a total capacity of 60 kW, supplying reliable, inexpensive electricity to localities in Muranga County. Magiro planned to upgrade the Kahinduini power plant from 26 kW to 60 kW and the Kiawambogo power plant from 18 kW to 50 kW in 2021. The company has benefited from the financial and technical support of the Government of Kenya and other international partners.[26]
- Emily Morris is a young female entrepreneur and founder of Emrgy Inc. which offers modular hydropower systems for distributed power generation and delivery in the USA. Emily led Emrgy to become the first company inducted into the City of Atlanta's Innovation Center to demonstrate new technologies on municipal infrastructure as well as the first company to receive equity investment directly from the City of Atlanta. In 2017, she led Emrgy to install the first distributed hydropower array in the USA with the City of Denver and the US Bureau of Reclamation.[27]
- If Governments want young people to be involved in the SHP sector, the most important enabling strategy would be to provide access to finance (grants for youth-led initiatives in SHP and scholarships) and create SHP entrepreneurship courses in universities resulting in young people acquiring relevant skills needed to start an SHP business. The Dominican Republic serves as a successful example of creating an enabling environment for SHP entrepreneurship through capacity building, providing incentives to start new companies and giving young people the opportunity to launch new product initiatives.

An additional incentive for youth involvement in the SHP sector can come from carbon credits. For instance, Elsia Paz of Energy Solution Partners, Honduras, suggests that SHP companies can obtain the gold standard for carbon credits faster and become eligible to sell their carbon credits worldwide, which implies increased profitability for SHP projects. This opportunity can make the SHP sector more attractive to young people. For example, Energy Solutions Partners was the first hydropower company in Honduras to obtain the gold standard for carbon credits. Presently, the company sells its carbon credits to Germany.

V. Major barriers affecting the involvement of young people in the SHP sector

While numerous and expanding opportunities for young people exist in the SHP sector, some barriers prevent young professionals from fully capitalizing on these opportunities. The following are key barriers identified that hinder the involvement of young people in the SHP sector:

- There is a lack of education about the importance of SHP in the overall global renewable energy mix, which results in the underutilization of SHP technology in some regions. Irrespective of the potential benefits of SHP projects, the technology has not yet received the required attention from many developing countries of the world.[28] As a result, many young people today remain unaware of the potential of this technology in improving energy access in their countries.
- In many countries, there is also a lack of specialized professional training programmes. For example, in Japan, education and training (technical and commercial) received in higher institutions have little relevance to the development of SHP and students are not provided with adequate knowledge in this field. There is also a scarcity of postgraduate training programmes for youth in SHP in the country, resulting in a scarcity of young professionals such as engineers, technicians and also qualified trainers.
- In some developing countries, young entrepreneurs do not have access to start-up capital to fund their SHP ideas and projects, which limits the contribution of young people in the sector.
- In non-English speaking countries, the language barrier can impede young people's involvement and contribution to the international SHP sector. SHP projects can require extensive international exposure, for example, when sourcing funding from international bodies (grants, pitching for prizes, competitions, etc.) or when seeking collaboration and networking at international events. This can lead to the exclusion of young people from some countries, especially young people from rural areas.

Other root barriers that affect the involvement and contribution of young people in the SHP sector include the following:

- Youth-blind policies, e.g., lack of inclusive public and workplace policies.
- Lack of inclusion of youth in decision-making and discussions about climate policy and energy transition.
- Lack of apprenticeships, paid internships and entry-level jobs.
- Lack of access to networks (many African countries, for example, do not have specialized professional networks for youth in the SHP sector).
- Lack of business partnership opportunities.

The following interventions are suggested to overcome some of the barriers that prevent young people from participating in the sector:

- Increase collaboration between the industry and educational institutions.
    - Raise student awareness of job opportunities and required skill sets through presentations by industry players at educational institutions.
    - Co-create modules centred on technical skills required in the SHP sector.
    - Establish apprenticeship or internship programmes to provide students and graduates with work experience in SHP companies.

- Invest in and encourage young entrepreneurs.
    - Reduce start-up capital constraints through grants and provide low-interest loan financing programmes.
    - Increase the number of local and regional innovation hubs and accelerator programmes to help entrepreneurs.

VI. Gender equality and empowerment of young women and girls in the SHP sector

Approximately 32 per cent of employees in the renewable energy sector are women, compared to 22 per cent in the energy sector overall.[29] Women make up only 28 per cent of the workforce in science, technology, engineering and math (STEM) and men vastly outnumber women majoring in most STEM fields in college.[30] Young women and girls are also underrepresented in the SHP sector although it provides multiple possibilities for them to lead, participate in and benefit from it.

The thematic section of the *WSHPDR 2022* "How SHP empowers women and closes gender gaps, and it can do more" explores the gender dimensions of SHP in detail, including the gender norms and roles that hinder women from equally leading, participating in and benefiting from SHP. Despite the many benefits that SHP can offer to women and girls and its capacity to empower women and close gender gaps, its full potential is limited by the range of gendered barriers women face on both the supply and demand sides of the SHP sector. These barriers are not due to the nature of SHP per se but relate to the longstanding gender norms and structural barriers, which in many societies means that women lag behind men in access to opportunities, incomes and assets as well as skills because of prevailing social norms.

Many of these barriers also apply to young women, such as traditional gender norms and roles and the subsequent lack of access to resources, time poverty and gender-based discrimination. However, in addition to the barriers that women face in general, young women and girls, in particular, are also discriminated against due to their age and therefore face multiple discrimination.

Therefore, it is not uncommon that there is an absence of data and information showing the involvement of young women and girls in SHP and neither the specific barriers that they face. To be socially sustainable, SHP programmes, projects and regulations need to address all dimensions of discrimination and when gender dimensions are mainstreamed, young women and girls require special attention. To improve gender equality and empower young women and girls in the SHP sector, the following recommendations can be made:

- Start early, changing gender stereotypes in school and providing positive role models.
- Provide education for young women and girls on STEM, fostering the interest of young women and girls in STEM fields.
- Provide paid traineeships for young women and girls.
- Work with the ecosystem (e.g., policymakers and the private sector) to create an enabling environment.

"SHP projects should focus on nearby communities, creating an enabling environment for young women to thrive economically. There is also an opportunity for women to gain project management skills. In the Dominican Republic, for example, in the implementation of community micro-hydropower projects the approach used by the entities that accompany the process is oriented to establish gender indicators for the creation of local committees to manage projects so that women can easily participate in the civil and political life of the communities. There is also the application of the principle of learning-by-doing: on the one hand, the project's approach must be tailored to specific local and gender contexts because rules that are appropriate for one community may not be applicable in another. On the other hand, the implementation of the project becomes a "school", where people, especially youth, can test their skills and strengthen their abilities. These types of projects, and specifically the model associated with them (the 'Universidad Del Campo' model), can teach a lot about improving women's participation in the SHP sector. This will also give women confidence in their ability to do difficult things in the sector and advance in their SHP careers." (Michela Izzo, Guakía Ambient, Dominican Republic)

VII. Skills required for young people to handle lead positions in SHP projects

Developing skills for green jobs, especially among the youth, can be an important driver of change, with new and better skills fostering innovation and triggering investment in green activities, thus accelerating the green transformation.[31] Adequate skills among workers and managers are requisite for advancing the green economy and creating green jobs for youth. However, the development of green sectors, such as renewable energy, has been hampered in many countries by a shortage of appropriate skills and technical expertise. It is therefore important to anticipate changes in skills requirements and adapt or reform technical and vocational training systems and programmes accordingly.

The following skills are critical for young people aiming to work and advance in the SHP industry:

- Fundamentals of hydraulic systems, electromechanical and civil engineering.
- Knowledge of geology and hydrology.
- Knowledge of economics and management.
- Language, communication and networking skills.

Overall, an attitude of lifelong learning is vital in SHP as there are so many intersections of technology, hydrology, natural resources, climate and geology that come together.

> "In Honduras, there is a general perception that young people who continuously keep abreast of novel technology, especially computer programming, have higher chances of being recruited and most SHP companies prefer hiring young people with such skills because they are expected to deliver clearer, concise and well-presented results." (Elsia Paz, AHER, Honduras)

VIII. Emerging technologies and innovative research areas in the SHP sector that young professionals can focus on

In the SHP sector, there is a demand for novel approaches to plant planning, design and operation. Emerging technologies and research areas cover SHP flexibility, digitalization, storage and variable speed turbines, generators with current-controlled rotors, as well as novel small-scale and fish-friendly technologies and offer opportunities to young professionals in the sector:

- Automation.
- River connectivity technologies at SHP plant locations.
- Relevant technologies for ecological restoration and protection of rivers.
- Greenhouse gas emissions measurements.
- Factors affecting aquatic habitats and river ecological protection technologies.
- Sediment shield erosion.
- Integration with other renewable energy technologies.
- Environmentally improved and low-head hydropower converters (vortex turbine, hydrostatic pressure machine, VLH and Girard-optimized turbines, hydrokinetic turbines).
- Novel designs of gravity hydraulic machines (such as water wheels and Archimedes screws).
- Advanced designs and operation strategies for pumps as turbines (PATs), which are common pumps with the ability to operate in a turbine mode, including the Deriaz turbine that is typically used in large-scale applications.
- Because of environmental concerns about hydropower, plant sustainability is increasingly being considered during the design stage. For low-head applications, fish-friendly turbines include Archimedes hydrodynamic screws, water

wheels and Vortex turbines, as well as the Alden turbine and the minimum gap runner turbine for higher heads. From an engineering standpoint, more research is needed to better understand the optimal design of fish passages about the swimming ability of fish and to determine the best locations to install inlets and outlets.

- Use of technology to collect more accurate data on potential SHP sites (via GIS).
- Novel materials for hydropower applications, particularly locally available materials that could enhance the performance and benefits of SHP. This would result in more efficient use of resources as well as a reduction in system costs due to a significant decrease in the cost of importation. Recent research has shown that composites can reduce the weight of steel equipment by 50–80 per cent, polymers and superhydrophobic materials can reduce head losses by 4–20 per cent and novel bearing materials can reduce bearing wear by 6 per cent.[32] These improvements determine higher efficiencies, longer life spans, waste reduction and maintenance needs, although the initial cost of some materials is not yet competitive with the cost of traditional materials.
- Production of spare parts locally, which would help increase system uptime while lowering operational and maintenance costs.
- Design, construction and deployment of containerised SHP solutions. This eliminates the need to transport materials to the site and facilitates easier and faster installation of the system as users have the opportunity to buy off-the-shelf. This is already changing the SHP landscape with the youth-led Emrgy's technologies, an example that other young people can emulate.[17]

Case study on a youth-led SHP project — Blupower

Blupower is a youth-led project in India that offers micro–hydropower solutions (15–200 kW) to harness renewable energy from very low-head streams with a target LCOE (Levelized Cost of Energy) of less than 0.03 USD/kWh. The project offers reliable, fish-friendly and easy to install micro–hydropower plants with maximum efficiency that does not require the construction of a dam. Based on the principles of biomimicry, the power plant uses a very low-head stream (below 5 metres) to generate energy close to the end user with basic civil works that can be done by local contractors. The plants are designed so that small debris can pass through the turbine, keeping maintenance low, while the control software keeps power production reliable.

The project aims to empower and bring reliable energy supply to remote areas. The Blupower team is currently pursuing Lab Test Validations on scaled laboratory models. As a start-up, they are focusing on small projects to assist small and medium enterprises and farmers to have reliable power for their production activities. In the long term, the company will build distributed turbines as an easy and eco-friendly way to create energy for small towns and regions that will become exporters of energy to other regions. The start-up is primarily funded through government grants and start-up accelerator programmes.

According to Blupower, some major barriers affecting the involvement of youth in the SHP sector include:

- Lack of STEM background.
- General misperception that field-based jobs require experience and physical strength.
- Careers in SHP are not promoted through formal channels.
- Lack of training and mentoring opportunities for young people in the SHP sector.

Blupower suggests that governments, international organizations as well as the private sector can support the participation of young professionals in the SHP sector by:

- Highlighting the role of young people as social actors and increasing the general understanding of young people's great potential as development partners.
- Fostering nationwide, systematic and continued professional information and career counselling.
- Developing start-up programmes for founding new businesses in the SHP sector.
- Facilitating access to green jobs for young people through targeted and adapted professional training programmes.
- Facilitating access to information about job vacancies through employment agencies.
- Encouraging the private sector to partner with young people by showcasing several case studies and demon-

strating the economic advantage of investing in young professionals.
- Providing initial guidance on facilitating private sector engagement with young people and the creation of meaningful partnerships to better influence development processes.

Conclusion

Renewable energy is one of the most promising options for achieving both the goals of youth employment and long-term social development. Youth involvement in renewable energy development, such as SHP, will provide significant benefits to rural communities. However, for SHP to be a viable and sustainable option for youth employment, particularly, in developing countries, increased and committed efforts in the sector are required. Increased investment in raising SHP awareness among youth is important so that young people can understand the potential of SHP and how it can help improve their standard of living. To accomplish this, there is a need to disseminate knowledge to a broad audience via a variety of media, such as websites, newsletters and workshops, among others.

Youth participation and leadership are critical for accelerating the development of the SHP sector and offering solutions to the existing energy challenges. Young people involved in SHP and those aiming to join the sector have great opportunities for entrepreneurship, professional growth and development once they are involved in the sector. They can contribute to the development, construction and commissioning of SHP plants and also their operation, maintenance and repair. However, young people continue to face a range of barriers in terms of accessing quality education and training, inclusive financial mechanisms and meaningful employment opportunities in the sector. Overcoming these barriers requires a collaborative effort aimed at improving the potential employment opportunities for youth. The following are some key recommendations for ensuring the involvement of young people in the development of SHP projects.

Recommendations

For Governments, International Organizations and the Private Sector

Recommendation 1: In SHP development, the governments' attention should be directed toward achieving gender equality and youth inclusion. Governments should develop youth-friendly policies for the SHP sector and ensure their implementation to achieve the desired impact. For example, the incorporation of incentives into programme funds and green recovery packages can encourage employers to hire, retain and advance more young people, including young women, in the SHP sector.

Recommendation 2: To have a meaningful impact, governments should take measures to raise awareness of the SHP technology and its potential benefits as a clean energy solution, while promoting environmentally responsible project development. For example, pilot SHP projects can be used to showcase to young people the value of this renewable energy solution and how it can be replicated in their communities.

Recommendation 3: Governments, international organizations and the private sector should make information about available systems of support for young people in the sector easily accessible so that young people can leverage the existing incentives and other opportunities.

Recommendation 4: Private institutions, international organizations and government institutions can collaborate to provide platforms for young people to explore innovative technologies in the SHP sector.

Recommendation 5: International organizations can play a key role in promoting exchange and cooperation on SHP technologies and the best practices among regions and countries, as well as enhancing public awareness and capacity building (provide training opportunities, paid trainee and entry-level positions and mentoring).

Recommendation 6: Governments should take the necessary steps to ensure that SHP is included in the curriculum for students at higher institutions and create training centres for young professionals who are interested in learning about SHP as a viable solution for energy access and community development.

Recommendation 7: Governments should increase funding for research on new technologies that can ensure the environmentally friendly operation of SHP plants. Usually, such research is funded from public sources and in most countries around the world is insufficient.

Recommendation 8: Governments should provide opportunities for capacity building in local environmental laws and regulations to create awareness of the environmental licensing procedures.

For Young People

Recommendation 1: Young people interested in the SHP sector should consider joining professional networks for accessing training opportunities, which can help accelerate the deployment of SHP projects in their local communities.

Recommendation 2: Brownfield projects are faster to reach the implementation stage than greenfield projects, thus, young people could take advantage of the brownfield potential for SHP development.

Recommendation 3: Young people can research novel technologies in SHP (for example, very low-head turbines).

Recommendation 4: Young people with an interest in joining the SHP sector should be proactive and reach out to the organizations they are interested in for job opportunities, internships and/or collaboration.

For SHP Developers

Recommendation 1: SHP developers should improve the working conditions and environment at SHP plants and sites by addressing the needs of young professionals, particularly women, and combatting possible challenges.

Recommendation 2: SHP developers should provide paid internship opportunities to boost the rate of integration of young people in the sector.

For SHP Professional Associations

Some educational programmes for young professionals entering the sector that SHP professional associations could focus on include:

- Industry foundations: Creating content that upskills young professionals new to the SHP industry will ensure their faster advancement within the SHP sector.
- Soft skills: Training in soft skills, including communication, leadership and language skills, will help create new opportunities for young professionals in the sector.
- Resume and interview coaching: Coaching young professionals on writing resumes and teaching interview skills can help advance their careers and ensure the SHP industry has qualified professionals entering the workforce.

Recognizing the full and active participation and leadership of women and youth is critical to achieving SHP development in communities. More recommendations on how the Government, SHP associations and developers can encourage young people and women's involvement in the sector are available at the Vienna Energy Forum Call to Action prepared in collaboration with UNIDO, Global Women Network for the Energy Transition and SDG 7 Youth Constituency.[33]

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