Brussels, 27 May 2022

COST 018/22

DECISION

Subject: Memorandum of Understanding for the implementation of the COST Action "Pan-European Network for Sustainable Hydropower" (PEN@Hydropower) CA21104

The COST Member Countries will find attached the Memorandum of Understanding for the COST Action Pan-European Network for Sustainable Hydropower approved by the Committee of Senior Officials through written procedure on 27 May 2022.

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA21104
PAN-EUROPEAN NETWORK FOR SUSTAINABLE HYDROPOWER (PEN@Hydropower)

The COST Members through the present Memorandum of Understanding (MoU) wish to undertake joint activities of mutual interest and declare their common intention to participate in the COST Action, referred to above and described in the Technical Annex of this MoU.

The Action will be carried out in accordance with the set of COST Implementation Rules approved by the Committee of Senior Officials (CSO), or any document amending or replacing them.

The main aim and objective of the Action is to establish and implement an effective and collaborative network in the field of sustainable hydropower sector for reaching the goal of Clean Energy Transition (CET) till 2050. This will be achieved through the specific objectives detailed in the Technical Annex.

The present MoU enters into force on the date of the approval of the COST Action by the CSO.

OVERVIEW

Summary
Hydropower (HP) played an essential role in Europe over decades, providing a unique combination of safe, low-cost, and clean electricity production. It is still one of the largest renewable energy sources (RES), adding up to about 35% of the electricity generated from RES. Predictions show that by 2024-2025 all RES will contribute almost 34% to the worldwide electricity production, and HP will provide approx. 50%.

Europe shows an almost equal share of electricity from volatile wind (36.5%) and predictable hydropower sources (34.3%) for 2019. This trend of an increasing quantity of unregulated energy (wind plus solar) involves market requirements for **flexibility and dynamics** such as energy storage and fast response. In that case, HP has the potential to balance a renewable energy system on a short term (seconds to minutes) and on a medium to long term (months or even years) basis by using pumped-storage technology.

New requirements in terms of operation and maintenance of Hydropower plants as well as co-generation of electricity with other RES needs substantial future research. As past funding of research projects was low, this new initiative should work together for a better knowledge exchange, **capacity building** of young researchers to meet the needs of the future.

The main objective of this Action is to establish a Pan-European network for a sustainable, digitalised Hydropower contributing to the **Clean Energy Transition** (CET), a united network of researchers, engineers, scholars, and other stakeholders, such as representatives from industry, policy and civil society, to facilitate close collaboration among European research groups through projects supporting sustainable Hydropower.

Areas of Expertise Relevant for the Action	**Keywords**
● Mechanical engineering: Applied mechanics, thermodynamics ● Electrical engineering, electronic engineering, Information engineering: Energy aspects of electrical and electronic engineering ● Civil engineering: Sustainable engineering, adaptation to long-term environmental changes ● Economics and business: Sustainability ● Earth and related Environmental sciences: Hydrology, water resources	● Hydropower ● Clean Energy Transition ● Sustainable Energy Production ● Low-Carbon Economy ● Climate change mitigation

Specific Objectives
To achieve the main objective described in this MoU, the following specific objectives shall be accomplished:

Research Coordination
● Evaluation and highlighting of the new role for Hydropower (HP) and Pumped Hydro Storage (PHS) within power sector in the coming decades 2030-2050 and beyond, considering the flexibility and energy storage needs of the future renewable energy sources dominated electricity systems, along with water hydraulics and ecology issues.
● Establish a scientific framework for HP producers/investors to improve the performance and competitiveness of existing and new HP and PHS plants within the European electricity system. It will include technological innovations in each plant's phase to enhance flexibility and efficiency within the environmental constraints and promote digitalization and predictive monitoring.
● Build a collaboration platform of scientists and stakeholders from various disciplines to develop a holistic

assessment and new approaches to support sustainable development and adaptation of the EU hydropower potential, considering the resilient infrastructure needs, the environmental and societal conditions, and the climate change forecasts for the coming decades.
● Mapping the current EU legislative and market framework, the CET scenarios, and identification of policy gaps and barriers to achieving the optimum balance between hydropower production and the environmental impacts to evaluate and promote the new role of hydropower in the changing energy and market needs.
● Development of a holistic scientific strategy based on consideration of digitalisation, climate change adaptation, a balance between production, industrial demands (WEF nexus), and environmental impacts of increased flexibility. Understanding of social acceptance, controversies, and policy improvement needs. Resulting in establishing a unique knowledge base currently missing in the scientific community.

Capacity Building
● Increasing the existing technical network by including additional disciplines, such as social, environmental and computer sciences through stakeholder outreach activities.
● Bringing Early Career Investigators into leadership positions while aiming for gender balance via a mentoring programme.
● Fostering career development of Early Career Investigators through joint PhD programs, knowledge transfer and Training Schools, with different disciplinary perspectives on sustainable HP and cross-disciplinary collaboration.
● Awareness creation for the importance of HP in the energy mix with focus on policymakers (in particular Europe) and industry via targeted dissemination activities.

TECHNICAL ANNEX

1. S&T EXCELLENCE

1.1. SOUNDNESS OF THE CHALLENGE

1.1.1. DESCRIPTION OF THE STATE OF THE ART

Hydropower (HP) played an essential role in the European Union over decades, providing a unique combination of safe, low-cost, and clean electricity production. It is still one of the largest renewable energy sources (RES), adding up to about 35% of the electricity generated from RES. Predictions of [2] show that by 2024-2025 all RES will contribute almost 34% to the worldwide electricity production, and HP will provide approx. 50%.

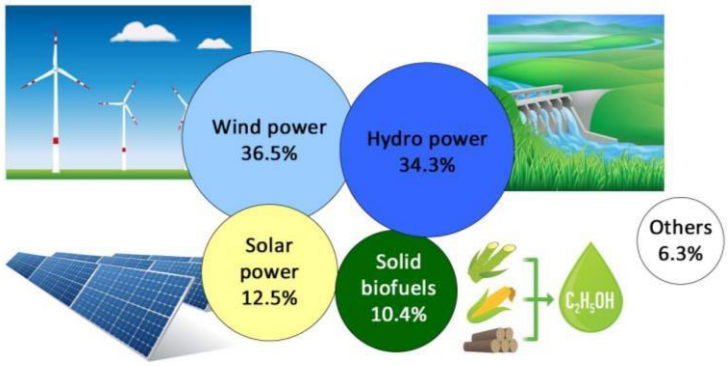


Fig. 1. Share of RES at electricity production in Europe [1]

Fig. 1 shows in the European Union an almost equal share of electricity from volatile wind (36.5%) and predictable hydropower sources (34.3%) for 2019. This trend of an increasing quantity of unregulated energy (wind plus solar) involves market requirements for flexibility and dynamics such as energy storage and fast response. In that case, HP has the potential [3] to balance a renewable energy system on a short term (seconds to minutes) and on a medium to long term (months or even years) basis by using pumped- storage technology. An additional phasing out of thermal energy sources will increase the strain on the Hydropower Plants (HPP) and change the standard operating patterns, bringing HPP to work in challenging and fatiguing operating conditions, for which HPPs equipment was not initially designed. Durable, resilient machinery sets and infrastructures are essential to achieve this goal.
Moreover, it cannot be disregarded that HPP are often part of integrated water management systems tackling flood protection, draught management, and freshwater provision. As the climate changes, these services will become more important. Ensuring that hydropower can continue to provide these services in the usual reliable manner in the decades to come requires sustainable measures [4] in plant design, construction, and operation phases. Hydropower is the only renewable resource with a Sustainability standard [5], unveiled in October 2021 by the International Hydropower Association (IHA) as part of the San José Declaration [6] for Sustainable Hydropower. In the course of these challenges of the future, digitalisation is becoming a game changer. Nevertheless, research projects will be necessary.
National research agencies and European Union supported research in hydropower for many decades. The amount of funding was very low in last decades, being approximately of 0.7% of total RES research funding (see Fig. 2). This is justified by the fact, that hydropower is regarded as a mature technology. However, changing role of hydropower (flexibility, resilience, digitalisation, sustainability) requires change in operation of hydropower plants, raising need for more research and networking activities.

HP can be the backbone of the future carbon-free European energy system, provide resilient infrastructure, and mitigate the global challenges posed by climate change [8]. Future research, development, and innovation should follow a holistic and crosscutting approach. Very often, discipline-oriented procedures were used without taking into account the needs and requirements of the others. Leaving this "silo-thinking" should result in crosscutting and multi-disciplinary approaches to hydropower research and a holistic perspective.
In that occasion research networks play a major role to connect different fields of expertise, young researchers, industry and society is challenging but crucial for the future. Research networks, such as the European Energy Research Alliance (EERA), Marie Sklodowska-Curie, and others, cover the academic community. At the same time, industry and business are represented by their own professional associations. A linking platform involving the society is currently non-existent but can be established through the COST Action PEN@Hydropower.

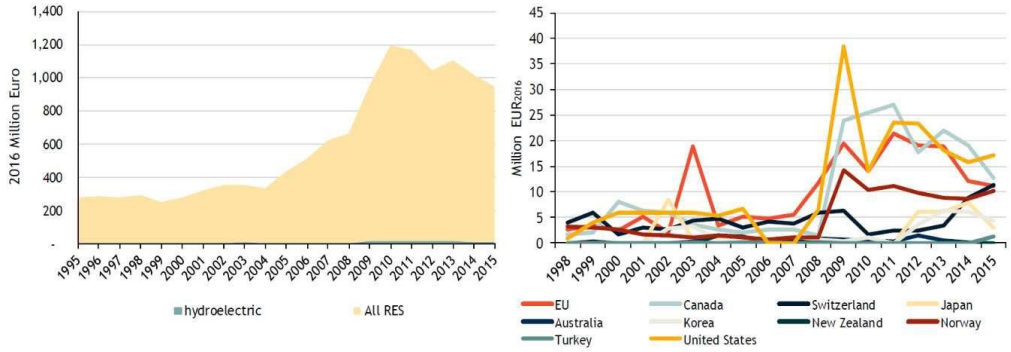


Fig. 2. RES and hydropower funding in EU (left) and worldwide (right) [7]

This COST Action will focus on 1.) defining a common language for a productive exchange along with different disciplines, 2.) building a research roadmap for a meaningful and cost- saving perspective, 3.) training of scientists or personal employees, 4.) defining novel holistic strategies in the context of HP, and 5.) ensuring sustainability to protect the environment and future generations.

Fig. 3. PEN@hydropower stakeholders (science, industry, society, associations, power producers, politics)

Moreover, the survey [7] enabled the network to identify the stakeholders (Fig. 3) and those interested in the COST Action at a later stage for specific tasks. This extensive contact network is a valuable asset that will be utilized during the COST Action period and beyond to grow the Hydropower community. This COST Action will transform the current fragmented state of the European Hydropower community by creating an effective and collaborative network, thus establishing the urgently needed interdisciplinary cooperation.

1.1.2. DESCRIPTION OF THE CHALLENGE (MAIN AIM)

The overarching challenge is to establish and implement an effective and collaborative network in the field of sustainable hydropower sector for reaching the goal of Clean Energy Transition (CET) till 2050.

CET decarbonization strategies of the energy sector are based on increasing the share of volatile renewable energy sources, requiring HP to play the new role of an enabler, providing not only

sustainable, reliable and secure energy supply at affordable prices, but also the much-needed flexibility. As flexibility is proportional to the rate of change in the discharge of water going through the turbines, the resulting fluctuation of water flow in rivers and reservoirs is typically unfavourable concerning all other users of the water systems e.g., agriculture, fishing, leisure activities. However, these flexibility and environmental needs will increase the strain on the HPP and change the normal operating patterns. The following **technological challenges** (CH01 - CH02) were identified:

CH01: Insufficient scientific support (0.7 % of EU RES funding [7]) to improvement of HP performance, flexible operation, and impaired river hydraulics and ecology (40% of EU rivers facing hydro morphological pressures [11]), including developing of novel technologies or improved models, equipment and services, and hybridization with other RES and storage technologies;

CH02: Limited scientific and technical support (only a few patents filed in hydropower [7]) for promotion of old power plants sustainability retrofits, new installations, and innovative lifetime models for resilient operation under new more demanding requirements.

The European HP system is in a state where the need for rehabilitation and new installations including pump storage is increasing, hence large investments are required in the next 20 years. At the same time, the energy markets are developing rapidly, where changes in policy and alternative technologies create uncertainty. How is best to support HPP operators and developers in taking appropriate decisions on future investments? The following **societal challenge** (CH03) was identified:

CH03: Lack of a comprehensive investment and site planning methodology, considering market development, LCA analysis, and climate change resulting in no new HPP additions within EU in 2020 [12]. This also reflects the contribution of RES to electricity production, with an apparent disparity between ITC and non-ITC countries. While 68% of non-ITC EU-countries exceed the EU27 average of 34.1%, only 27% of ITC EU-countries reach this value [1]. HP investments go hand in hand with new jobs and employment. Considering this, raising the CET and social aspect is needed at this point.

HP is providing for a third of EU RES electric energy. As shown above, HP has received disproportional low amount of funding through the European Union and national projects, dramatically limiting the capacity of EU HP research sector. How HP will be able to cope with the above three scientific and social challenges while at the same time being ready for the digitalisation era with increasing demands for personnel, security, asset lifetime, etc? The following **networking challenge** (CH04) must urgently be addressed:

CH04: Poorly organized EU HP scientific environment (only 15 HP projects funded from FP6 to H2020 [7]) unable of holistic assessment of operation of HP under state-of-the-art requirements by including the digitalisation, sustainability, circularity, WEF (water, energy, food) nexus, environmental and societal aspects throughout the HP life cycle.

1.2. PROGRESS BEYOND THE STATE OF THE ART

1.2.1. APPROACH TO THE CHALLENGE AND PROGRESS BEYOND THE STATE OF THE ART

Although HP is largely perceived as a mature technology, both the current and foreseeable challenges described above require intensive scientific research and technological development efforts. The sheer size of HP investments led to a rather conservative approach, where mostly incremental steps are considered while maintaining as much as possible the simple and robust technical solutions established more than a century ago. It becomes increasingly obvious that this rather prudent and technology-oriented approach has little chance to deliver highly innovative solutions. Defining the roadmap to the future generation of HP, technological goals have to be approached by taking into account the constraints and challenges posed by several dimensions interconnected with the HP, notably economy, markets, environment and public society, R&D, legal framework, and climate change (see also Fig. 3 of complex interaction of all factors in [9]).

In a nutshell, [9] identifies primary R&D priorities:

- Increasing **Flexibility**
- **Optimisation** of operations and maintenance through digitalisation
- **Resilience** of electromechanical equipment and infrastructures
- Developing **new emerging concepts**

- **Environment**ally compatible solutions
- **Mitigating** impact of **global warming**

The development of innovative and cross-sectoral solutions for these complex HP challenges requires a completely new research approach based on the expertise of all fields linked with sustainable HP (technology, society, economics and environment) and from a diversity of geographical and stakeholder contexts.
Hence, the PEN@Hydropower Action aims at creating a networking ecosystem for the definition of this new research approach with the following characteristics:

- Variety of expertise encompassing disciplines such as Mechanical Eng., Civil Eng., Environmental Eng., Social Sciences, Electr. & ICT Eng., Earth & Environm. Sciences, Economics & Business, Physics, Appl. Mathem. & ICT and of Biol. and Agriculture. This variety will guarantee knowledge sharing between research fields during the networking activities, favouring a mutual understanding of crosscutting constraints and challenges.
- Variety of working fields: academia and research centres combine with NGOs, business enterprise, Government/Intergovernmental Organizations and Standards Organizations. The networking activities will enable discussions among actors and facilitate trade-offs between competing interests.
- Pan-European characteristics with European partners with connection even to international partner countries and near neighbour countries. The European partners should represent an excellent geographical distribution with significant participation of ITCs. Thus, the different economic, societal and environmental contexts, characterizing the different countries are reflected.

Within this network, the COST Action will promote cross-disciplinary activities with the aim of knowledge sharing, boost new interlinked collaborations and put the basis for holistic solutions to the complex challenges of building a sustainable hydropower. Activities are documented and quantified in section 3.2.2, while timeframe is provided in section 4.1.4.

The ecosystem, raising from the PEN@Hydropower Action, is in line with [10] and will promote the onset of a new generation of HP researchers, naturally educated for crosscutting and interlinked research projects with the final aim of building sustainable and flexible HP. On this occasion 4 Summer/Training Schools will established and at least 4 Short-Term Scientific Mission (STSM) calls will be launched.

1.2.2. OBJECTIVES

1.2.2.1 Research Coordination Objectives

The main objective of this COST Action is to establish a Pan-European network for a sustainable, digitalised HP contributing to the CET, a united network of researchers, engineers, scholars, and other stakeholders, such as representatives from industry, policy and civil society, to facilitate close collaboration among European research groups through projects supporting sustainable HP.
The PEN@Hydropower Action will meet the following research coordination objectives (RCO), which are correlated with the corresponding Working Groups:

RCO-01 Evaluation and highlighting of the new role for HP and Pumped Hydro Storage (PHS) within power sector in the coming decades 2030-2050 and beyond, considering the flexibility and energy storage needs of the future RES dominated electricity systems, along with water hydraulics and ecology issues, through interdisciplinary events: organisation of side events at 4 international conferences and 4 multidisciplinary workshops (Addressing CH01)

RCO-02: Scientific support framework for HP producers and investors to improve the performance and competitiveness of existing and new HP and PHS plants within the European electricity system and energy market. It will include the on-going technological innovations in the design and construction, upgrading and refurbishment, and operation strategy of the plants, in order to enhance their flexibility and efficiency within the environmental constraints, and to promote digitalization and predictive monitoring. Through 4 thematic workshops and an accordingly organized database, accessible through the internet that will be continuously enriched during the whole project period. (Addressing CH01 and CH02)

RCO-03: Collaboration platform of scientists and stakeholders from various disciplines (engineering, ICT, environment and climate, hydrology, social, financing, etc.), in order to develop a holistic assessment and new approaches to support sustainable development and adaptation of the

EU hydropower potential, considering the resilient infrastructure needs, the environmental and societal conditions, and the climate change forecasts for the coming decades. Through the 4 multidisciplinary and thematic workshops, and the 4 summer schools envisaged in the Action. (Addressing CH02 and CH03)

RCO-04: Mapping of the current EU legislative and market framework, and the CET scenarios, and identification of policy gaps and barriers to the achievement of the optimum balance between hydropower production and the environmental impacts, in order to evaluate and promote the new role of hydropower in the changing energy and market needs. Through discussions and interaction with different stakeholders like policy makers, HP developers and producers, EU commission, regulators, NGOs, etc., during the 8 workshops, 24 meetings and 4 conference side events of the Action. (Addressing CH03 and CH04).

RCO-05: Development of novel holistic scientific HP community strategy based on harmonized use and consideration of: digitalisation, climate change adaptation strategy, balance between production, industrial demands (WEF nexus) and environmental impacts of increased flexibility, understanding of social acceptance and controversies, and policy improvement needs. This will result in an establishment of a unique knowledge base, currently missing in the scientific community. Through scientific dissemination and knowledge creation workshops and conferences, and a public consultation/questionnaire that will be sent to all stakeholders. (Addressing CH04).

1.2.2.2 Capacity-building Objectives

Specifically, this COST Action will contribute to capacity building by meeting the following objectives (CBO):

CBO-01: **Increasing the existing technical network by including additional disciplines, such as social, environmental and computer, sciences through stakeholder outreach activities:** (a) Regular networking of researchers from different regions of Europe and from different disciplines (see 1.2.1) during Working Group (WG) meetings, debating on issues of sustainable and digitalized HP to foster knowledge exchange; (b) increasing the opportunities for building new research teams by cooperation in the Action's framework during 4 Thematic Workshops (TW); (c) 4 International Conference (IC) side events aligned with big events relevant to the sustainable hydropower to address people outside of the regular community.

CBO-02: **Bringing Early Career Investigators into leadership positions while aiming for gender balance**. A mentoring programme is organized by the Management Committee (MC), offering each Early Career Investigator (ECI) in the position of WG leaders or co-leaders 1 senior mentor for the duration of the COST Action. The aim is to encourage ECI's to take leadership roles. The COST action aims to reach gender equality of the WG leaders or co-leaders and involvement of ITC countries. 3 Group-Mentoring (GM) events attached to MC meetings will be organized for peer- mentoring and exchange.

CBO-03: **Fostering career development of Early Career Investigators through joint PhD programs, knowledge transfer and Training Schools, with different disciplinary perspectives on sustainable HP and cross-disciplinary collaboration:** ECIs will participate in 6 WGs, 24 Core Group (CG)-Meetings, 4 STSM calls and international joint research programs and co-lead the WGs. 4 Summer/Training Schools (TS) with the aim to provide ECIs with different disciplinary perspectives on sustainable HP and train them in cross-disciplinary collaboration. The aim of this action is to hold 50% of the summer/training schools at ITC countries. Teaching material will be available later on as deliverables.

CBO-04: **Awareness creation for the importance of HP in the energy mix with focus on policymakers (in particular Europe) and industry via targeted dissemination activities** (dissemination workshops, video, policy briefs, state-of-the-art reports etc.).

2. NETWORKING EXCELLENCE

2.1. ADDED VALUE OF NETWORKING IN S&T EXCELLENCE

2.1.1. ADDED VALUE IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

This is the first COST Action on Hydropower with focus on Technology and Sustainability to support Europe's energy transition at the coming future decades. It has an added value in relation to a bulk of former and existing efforts, of which only the most relevant will be described due to the page limit of this Technical Annex.

The HP sector has produced, over the last years, numerous important projects. The main ones aim to demonstrate how flexible HP technologies can deliver a low-carbon, secure and resilient power system. The goal is to introduce new HP technologies such as smart controls, enhanced variable- and fixed-speed turbine systems. More specifically, they try to develop the technology permitting highly flexible operation of HP stations, within (strict) excellent environmental and social conditions while being economically competitive. Other projects seek to improve specific technologies, like reversible pump/turbine (RPT), and to contextualise them in civil engineering and local needs.

In terms of currently existing research networks, the HP field shows promising potential for collaboration. At the European level, cooperation among researchers spans the entire energy chain from water catchment to system integration, and it explores crosscutting elements such as markets and market design, environmental impacts, effects of climate change and policy and societal issues. The existing networks also provide, although limited in time and scope, forums for the European HP community and representatives active throughout the sector's entire value chain, including industry, researchers, policy makers, end users and academia.

This PEN@Hydropower COST Action addresses the HP sector with a strong emphasis on multidisciplinary approaches. It gathers together perspectives from the fields of engineering, social sciences, economics, law, environmental sciences, that have not extensively been included in previous projects. Furthermore, it focusses on the active role of stakeholders in all planned activities.

2.2. ADDED VALUE OF NETWORKING IN IMPACT

2.2.1. SECURING THE CRITICAL MASS AND EXPERTISE

At proposal stage the PEN@Hydropower Action's Network of Proposers consists of 51 members from 33 countries: 44 members from 28 COST Member Countries, including 16 COST Inclusiveness Target Countries (ITC); 2 member from 2 COST Near Neighbour Country (Ukraine, Russia); and 5 members from 3 International Partner Countries (Canada, Nepal, India); ranging from Young Researchers and Early Career Investigators (ECI) to senior researchers. This Network of Proposers represents an excellent mixture of various disciplinary expertise in HP, like Mechanical engineering, Environmental engineering, Civil engineering, Electrical engineering, electronic engineering, Information engineering, Earth and related Environmental sciences and others. While 72.5% come from academia, research institutes and associated organisations, 11.8% from NGO's, 9.8% from Business enterprises, 3.9% from Governmental Organisations and 2.0% from Standards Organisations. To build a Pan-European Network for sustainable HP that supports Europe's energy transition and climate change mitigation and fosters the development of sustainable societies. The Action's Network of Proposers covers all geographical regions of Europe. This is – especially important for mutual learning. The experience from warmer or dryer regions, for example, will be crucial for other regions expecting a warmer climate in the future.

2.2.2. INVOLVEMENT OF STAKEHOLDERS

The active involvement of relevant stakeholders from different sectors is crucial for assuring long-lasting impact and continuity of the Action. Progresses will be monitored by the Management Committee (MC). The involvement in PEN@Hydropower Action is structured in five levels:

1. Participants of the COST Action, either as MC members or as WG participants
2. Targeted contacts: Companies and research groups identified during the technology screening activities in WGs; regulatory bodies relevant to Hydropower
3. Broader scientific community: Contacts established via conferences, seminars, workshops and publications with a special focus on ITCs
4. Involvement of regulatory and political authorities, global associations and interest groups
5. General public: Contacts established via public awareness activities through social media platforms

At **levels 1-3**, already known or targeted persons are directly involved, like for example CA20138 "NEXUSNET", while at **levels 4-5**, an identification procedure is required to find the responsible person to be involved. This identification process is based on personal contacts and, on the other hand, through actions such as social media calls, unique submission opportunities at conferences, and thematic workshops. WG 5 will take care of the involvement of the necessary stakeholders and their accessibility. Expertise of not yet personally identified stakeholders are requested in sectors of sustainability, climate change mitigation, social acceptance, and holistic assessment. Involvement of already invited stakeholders can occur on different levels, such as Global Women's Network for the Energy Transition (GWNET) in the mentoring program for young ECIs or European Renewable Energies Federation (EREF), International Hydropower Association (IHA), International Association for Hydro-Environment Engineering and Research (IAHR) Young Professionals Congress, VGB PowerTech e.V. (VGB) in policy analysis, or World Wide Fund For Nature (WWF) in terms of sustainability.

2.2.3. MUTUAL BENEFITS OF THE INVOLVEMENT OF SECONDARY PROPOSERS FROM NEAR NEIGHBOUR OR INTERNATIONAL PARTNER COUNTRIES OR INTERNATIONAL ORGANISATIONS

Invited members from Near Neighbour Countries (Eastern Europe) and International Partner Countries (Canada, India and Nepal) have been selected due to the importance of HP in their electricity production. Canada (Province of Quebec) covers 99% of its demand through HP. Prof. Sebastien Houde, Maud Demarty and Jonathan Nicolle work since years in the field of Hydropower in Canada and can share their findings within WG or MC meetings. They enrich the community with Canadian point of view. Nepal has one of the highest hydrological potentials worldwide and the share of HP will increase significantly (from 1% to 80% electricity produced by hydropower) within the next decades. Former Dean and Prof. at the Institute of Engineering at the Tribhuvan University Prof. Tri- Ratna Bajracharya brings special knowledge on hydropower development from a developing country. Not only technical issues are there to be fulfilled but also social, environmental and climate issues have to be considered. Especially the Himalayan Region faces today big changes in glacier melting and changing water supply. Same applies to India, where big power demand leads to an increase of the production side. Prof. Saini works at IIT Roorkee since several years in the field of hydraulic machinery and can share this central Asian view with all partners. Ukraine insight to this topic will be brought by Dr. Yuri Boykov and his colleagues from the National Academy of Science. Especially eastern information on Hydropower plant operation and maintenance will be of high interest for all other participants. The Canadian, Eastern Europe and Asian members are invited to act as MC Observers.

3. IMPACT

3.1. IMPACT TO SCIENCE, SOCIETY AND COMPETITIVENESS, AND POTENTIAL FOR INNOVATION/BREAKTHROUGHS

3.1.1. SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS (INCLUDING POTENTIAL INNOVATIONS AND/OR BREAKTHROUGHS)

PEN@Hydropower Action is an ambitious framework and will provide a comprehensive set of "good practices", identifying open research questions and achieving multi-directional relationships to tackle them, and ensuring feedbacks and contributions to the project activities. The assessment of social acceptance and cost-effectiveness of the energy transformation measures will include aspects such as business focus and identification of potential risks & negative effects, as well as the main direct and indirect benefits. PEN@Hydropower Action will be multi-disciplinary and will provide a range of short term (while the Action is running) and long-term (after the Action) impacts as follows.

Expected Impact	Scientific	Technological	Socio-economic/Environmental
Short-term (within COST Action project duration)	Promoting academic creativity leading to joint publications based on the availability of comparative knowledge, through interdisciplinary discourse and through the structural analogy of situations that were previously unrelated.	Develop and implement a knowledge exchange platform to promote a consultation process between the industrial sector and academia; host joint workshops to boost innovativeness.	Raising awareness among all stakeholders regarding socioeconomic, social, environmental and climate change aspects in relation with HP; triggering mutual learning, also across countries, State traditions, governmental levels and policy sectors.
Long-term (beyond COST Action project duration)	Development of a theoretical framework for intergovernmental coordination at local, regional, national and supranational levels as a basis for future research; emergence of new research collaborations and acquisition of funding across (sub-)disciplines and countries to spread the holistic approach as far as possible.	Europe will in the long-term benefit from world leading performance of hydropower industrial sector. The COST Action contributes in educating future experts needed in this industry, as well as the new generation of researchers. Extensive use of web based platforms to provide and disseminate information enables knowledge sharing, networking, and consultation; use crowdsourcing techniques to keep platform content up to date.	Novel EU energy requirements and flexible coupling with other energy sources will bring support of the general population and decision makers for novel hydropower role. The knowledge gained by the COST Action will support decision makers on a long-term with regard to relevant regulations.

Together, the three levels of impact identified above will contribute to facilitating a new role for HP in Europe and the world. In addition to innovations and contribution to national and international programs, this COST Action will result in several ECIs who are highly trained to be able to work on novel

hydropower role in the decades to come. This will be achieved by increased mobility through Training Schools and Short-Term Scientific Missions, while building their leadership skills.
Finally, the impact of generated knowledge from the COST Action will contribute to placing Europe in a highly competitive position in the sustainable hydropower sector, which will provide opportunities to collaborate and export the state-of-the-art knowledge, technologies, and services to emerging countries that are intensively involved in energy sustainability efforts.

3.2. MEASURES TO MAXIMISE IMPACT

3.2.1. KNOWLEDGE CREATION, TRANSFER OF KNOWLEDGE AND CAREER DEVELOPMENT

KNOWLEDGE CREATION: The COST Action will strongly contribute to establishing a fruitful network based on joint activities and social interactions to promote stronger knowledge creation and sharing within the industry, end-users, and academic communities belonging to the European hydropower and broader energy sectors. In particular, to support the creation of new and novel ideas we enforce during the WG meetings, an inclusion and exchange among the PhD students of the participating research groups, so ideas can better be transferred, and collaboration among young researchers can be initiated.
TRANSFER KNOWLEDGE: By leveraging the knowledge outputs of all WGs, the framework will transfer knowledge among the partners and ensure the broad applicability of the results, taking into consideration regulations and standards. Thanks to the joint force of leading scientists in the hydropower sectors, the organization of summer/training schools for both young professionals and students at different degree levels will motivate the new generations to pursue their career in the sector and enrich their skills, e.g. in interdisciplinary collaboration. This also includes the promotion of on-site exchanges once a year, during the runtime of the action.
The educational materials, together with open access scientific publications and a living document gathering the knowledge built within the COST Action activities, will be accessible and promoted to universities, research institutes and professionals to support relevant continuing education programs beyond PEN@Hydropower Action.
In addition, the broader public will be addressed by providing the Actions website as an access point for the interested public with relevant information, e.g. via White papers addressing the interested public, enabling them to participate in the dialogue of the future role of HP.
CAREER DEVELOPMENT: As outlined before, the career development for young researchers, both in academia and industry plays a key role for the Action. Empowering and enabling them by providing them with the needed mobility, but also various inputs from different disciplines, and include them in the running of the framework.
Once a year workshops and summer/training schools will be organised each in different regions to engage different stakeholders. Each of these trainings shall be organized by one of the corresponding WGs, and aligned with their research challenges, to help participants to obtain relevant inputs, and allow them for creating impactful contributions in their future activities. Young researchers form an important pillar to sustain the impacts of the COST Action beyond its lifetime, and therefore will be not only supported by it, but also be actively included, e.g. by co-leading working groups.
Mobility is today a key enabler to gain precious experiences and to leap in the career. The COST Action will weave an ambitious mobility scheme to boost the knowledge transfer and enhance the international collaborations between the participants. In particular, joint PhD programs, short-term exchange periods and webinars will be organized as compelling initiatives. This includes exchanges with academics, as well as with industry partners of the COST Action, leading to various different experiences, which can help career development in either of these fields.
The Action will thereby focus on applying inclusiveness is a paramount principle in the activities of PEN@Hydropower. Career stage and gender balance are considered to ensure a low-barrier entry for women, ECIs and other early career professionals to the network.

Impact by Country	The Action will enable neighbouring countries that face greater networking difficulties to become part of a network of excellence in hydropower; at the same time, researchers from COST countries will broaden their employment prospects in the EU. Particular attention will be paid to improving the competitiveness of researchers from ITC countries.
Impact by Gender	Following COST policies and recommendations, gender inclusiveness is a main focus of this Action. Female scholars shall be granted equal opportunities in both participation and leading positions within the Action as well as in the attribution of ITC Grants and STSMs.
Impact in Career	The COST ACTION should serve as a career booster for ECI's. Involvement in management positions and training schools will have a great impact to the young careers of the participants. In terms of female participants, an additional mentoring program will empower the career development.

3.2.2. PLAN FOR DISSEMINATION AND/OR EXPLOITATION AND DIALOGUE WITH THE GENERAL PUBLIC OR POLICY

The overarching goal of the dissemination activities in each Working Group (WG) of the COST Action is to raise awareness and interest of target audiences, while also supporting knowledge transfer of outputs to potential users and amplifying interactions with stakeholders. The target audiences include stakeholders in the hydropower sector such as equipment manufacturers, hydropower plant operators, financial and government institutions, policymakers, universities and research institutes, but also public such as engaged citizens, social media users and bloggers.
For this purpose, the dissemination plan to maximize the COST Action impact includes the following tools.

PROJECT WEBSITE (PW: 1)	A public project website will be built to provide the key project information and host a virtual knowledge hub, which provides information and multimedia content about the COST Action activities and outputs. High-quality, engaging and accessible content will be generated throughout the lifetime of the project, with regular updates every 1 month, which conveys key messages to target audiences across a variety of media. Multimedia content will include both interactive and animated content to facilitate the audience engagement. At least 5.000 visit and content visualization are expected during the project.
PRESS RELEASE (PR: 2)	1 press release will be organised on the occasion of the Kick-Off Meeting (KM) of PEN@Hydropower Action,1 at the end of the project and issued to target media. There will also be 2 press releases following the round-table discussions planned within WG3 and WG4. Partners will send press release with a quote from their spokesperson to their in-country media contacts. It will be spread through at least 30 countries.
NEWS- LETTER (NL: 8)	Publishing regular 8 newsletter updates will ensure that the target audiences are regularly appraised of the COST Action activities and achievements, and have the opportunity to respond to challenges. Production of the newsletters will involve gathering, editing and organising content from partners in a concise and easy-to-digest format. Transmission will be by electronic means targeting at least 500 subscriptions.
WORK-SHOPS (WS: 4) and ROUND-TABLES (RT: 4)	4 dedicated online webinars will be arranged for target audiences to showcase PEN@Hydropower Action, its activities and resources among European and also non-European stakeholders. 4 Roundtables will be also organized to emphasize the discussion among experts and bring new interesting prospective for the collaborations. Each activity is expected to attract the interest of at least 100 participants.

CONFERENCES (IC: 4)	PEN@Hydropower activities will be presented with oral presentations and posters at the upmost important International Conferences (IC) of the hydropower sector. Each WG will produce at least 3 scientific contributions to give visibility to the COST Action activities in these events. 4 international conferences/congresses/symposiums/workgroups will be selected during the project. Dedicated grants (approx. 8) for helping PhD students and ECIs COST Inclusiveness Target Countries (ITC) to attend international science and technology conferences that are not specifically organised by the framework are foreseen.
PEER-REVIEWED PUBLICATIONS (RP: 2)	The publication of the results achieved within the collaborations established in the COST Action targets top quality scientific journals and hydropower sector magazines. These are mainly oriented to reach the hydropower community, but also network operators, utilities, scientific institutions, policymakers, etc. The publication of joint review articles will help to disseminate results to a broader, less specialized public. All peer reviewed publications will be "green" open access and made freely and openly available via online repository. The scheme will guarantee the data utilised in scientific publications is reusable and accessible. At least 2 peer-reviewed publications are expected for each WG during the duration of the COST Action.
LIVING DOCUMENT (LD: 1)	The COST Action will produce a compendium (1) comprising all WGs activities outputs to build a comprehensive reference document for the enhancement of the hydropower sector through the 2050 European energy transition.
TRAINING/ SUMMER SCHOOLS (TS: 4)	4 international and local educational activities will be organized to transfer knowledge among young professional and students at different degree levels, targeting minimum 50 participants. They will be open to interested public to raise awareness of the activities and interest on the topics. Activities will include open day at selected hydropower plants, open street lectures and social events such as the Night of Science, Science Cafes. Experts will be invited as speakers to facilitate access to the latest developments. COST ITCs and ECIs will be prioritised to hold and attend these activities.
SOCIAL MEDIA (SM: 24)	Social media (including LinkedIn, Twitter, YouTube and Facebook) will be harnessed to promote key messages using a strategy, which focuses on generating and sharing every month compelling, highly visual and interactive engagement to increase awareness about hydropower and its irreplaceable role in energy transition. Short, well structured, easy to comprehend messages will be targeted on broad public, not only experts in the field. Dedicated new, and existing, social network channels of PEN@Hydropower partners will be exploited to enhance engagement with existing and new stakeholder communities. Social media engagement with local communities will be directly managed by the teams in the region exploiting local social media targeting 500 followers and 1000 visualizations of each content at a minimum. Facebook will be updated at least 6 times per year, LinkedIn and Twitter contributions are planned at least 4 times per year.

4. IMPLEMENTATION

4.1. COHERENCE AND EFFECTIVENESS OF THE WORKPLAN

4.1.1. DESCRIPTION OF WORKING GROUPS, TASKS AND ACTIVITIES

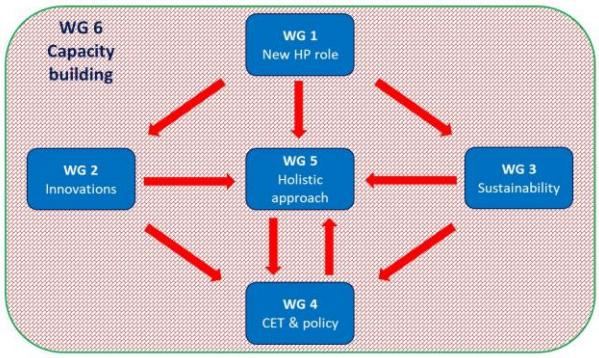


Fig. 5. Interaction of all WG's.

Results of technical WG1 are needed as input for innovation WG2. Considering these results and adding special issues on sustainability and climate change mitigation leads to the content of WG3. That output will be applied on a European level, checking the CET implementation at national countries leading to the output of WG4. All in- and outcomes will be combined in a holistic assessment at WG5, leading to capacity building in WG6, which is again starting point of WG1. It is a life cycle in hydropower assessment and capacity building for future challenges in this field.
However, the formal structure of the six WGs will be arranged in place to reflect the goals and to deliver the objectives of the Action by fulfilling the specific tasks (T):

WG 1 – Hydropower Role in Flexible Energy Synergies

Description	Within WG1, the Action will focus mainly on the conditions for the use of hydropower within flexible systems. Attention will be paid to the assumptions and trends of electricity accumulation for various water sources and conditions, innovative systems and monitoring options. (Addresses CH01 & RCO-01)
Tasks	T1.1 Understanding the basic assumptions and trends of electricity accumulation for different water sources and conditions T1.2 Innovative approaches to Network energy storage related to networks and flexible solutions, e.g., innovative electricity generation management systems T1.3 Defining the best monitoring and management of electricity storage sources in relation to hydropower
WG-Activities	• Discussion on the importance of the use of hydropower concerning on the flexibility, storage, reliability during COST meetings • Linking local stakeholder groups (LSGs) (academic, industrial and governmental) in the electrical part of Hydropower use to identify weaknesses in Hydropower intensification • Discussion with the LSGs on the condition for settlement the Hydropower as one bedrock of clean and secure electricity for future

WG 2 – Technological Evolution Through Innovation & Digitalisation

Description	In this WG, the technological evolution requirements for innovative solutions are explored to tackle the foreseen ambitious scenarios. Additionally, digitalization aspects have to be considered. They will pave the way toward increasing hydropower competitiveness and enhancing grid flexibility, stability, safety, and

	resilience. Multidisciplinary approaches (mechanical and electrical engineering, ICT, environmental engineering, trading) will achieve these goals, combining massive sensor deployment, AI and big data processing, building forecast models, and digital twins. (Addresses CH01, CH02 & RCO-02)
Tasks	T2.1 Classification and reviewing of available disruptive technologies and innovative concepts in the hydropower sector including technical, environmental and economic constrains targeting ancillary services markets challenges where flexibility is valorised; T2.2 Assessing and defining current barriers for digitalization in hydropower sector (technical, economic and social aspects), outlining trends in predictive operation and maintenance and defining strategy for implementation of digitalization for upgraded or refurbished hydropower plants.
WG-Activities	• Establishing pan-European collaboration on disruptive technologies in hydropower and strategies for further enhancements. • Multidisciplinary workshops with experts across mechanical engineering (turbine and equipment innovations, lifetime predictions, digital twin), electrical engineering (generator, smart grid, distributed energy sources), business (trading, block chain, workforce management), ecology and sustainability (weather variability and climate changes), IT (big data, clouds, artificial intelligence, cybersecurity) to cover all aspects of digitalization and their mutual interactions.

WG 3 – Sustainable hydropower and its adaptation to climate change

Description	Cross-disciplinary collaboration is needed to facilitate sustainable development in the Hydropower sector which considers industrial-, environmental- and societal needs in a changing climate. To realize the potential of Hydropower in a flexible modern energy system, new technological developments must be combined with state-of-the-art climate projections, environmental and societal conditions to provide planning and implementation tools for legislation and governance. (Addresses CH02 & RCO-03)
Tasks	T3.1 Identification and classification of local environmental impacts and mitigation methods coupled to hydropower in regulated rivers for current scenarios as well as future scenarios and impacts effected by climate change (fulfil European Water Framework or other goals). T3.2 Establishing pan-European collaboration on climate change projections, hydraulic modelling, their impact on hydropower, and possible strategies to adapt to the changing climate in terms of safety, ecology and social activities
WG-Activities	• Organize activities (workshops, summer schools) with discussions on local environmental impacts in terms of regional conditions and their susceptibility to climate change

WG 4 – Clean Energy Transition and policy measures

Description	This WG will focus on understanding and identification of major trends, restructuring the power sector in the following decades. Within the process, cross-sector couplings will be identified and novel hydropower role will be evaluated. Evaluation will be based on EU frameworks and directives, CET and trends. (Addresses CH03 & RCO-04)
Tasks	T4.1 Understanding the EU frameworks trends of generation (distributed and non-dispatchable renewables) and consumption (prosumers, demands for further electrification). Evaluation of hydropower role and operation in EU members, evaluation of market development for EU equipment producers T4.2 Requirements and simulations of future hydropower to X coupling (energy storage, power to fuel, power to gas, other energy conversions) T4.3 Evaluation and prediction for the novel role of hydropower - requirements for construction, refurbishment, maintenance and operation from 2030 to 2050. Identification of policy gaps, outdated policies, policies that need

	improvement. Assessment of short- and long-term PEN@Hydropower scenarios.
WG-Activities	• Discussions on energy transition and facilitation of cooperation among energy sectors, including universities and companies during conferences, meetings and summer schools, involving all relevant branches of science. • Interaction with equipment producers, energy producers, EU commission and agencies, EERA, organisations, NGOs, regulators, etc. on energy transition.

WG 5 – Holistic assessment and stakeholder interaction

Description	An urgent need for holistic assessment of hydropower using much improved stakeholders interaction was identified. By holistic the Action means realizing of all aspects of hydropower, not only technical (e.g., lifetime extension) or environmental (e.g. biodiversity, local climate change), but also societal (reception by residents) and financial (e.g., return of investment and reasonable profitability). Policy suggestions based on PEN@Hydropower best practices and future scenarios as well as stakeholders outreach and engagement. (Addresses CH04 & RCO-05)
Tasks	T5.1 Evaluate economical balance of flexible production, industrial demands (e.g., Water-Energy nexus) and environmental impacts (global and local) while preserving dam safety in a changing climate. T5.2 Investigate social acceptance and controversies related to (flexible) hydropower, develop new forms of public engagement and provide input to policy makers regarding new laws and regulations, climate strategies, and citizen participation processes. T5.3 Proposals to improve the identified policy issues by exploiting results derived by WGs 1- 4 and considering future scenarios.
WG-Activities	• Integrating the WGs outcomes into policy strategies and roadmaps. • Cooperation among partners and stakeholders with European, national, regional and local hydropower operators.

WG 6 – Outreach, organization and monitoring of events

Description	Communication and dissemination of the results and organization of Action's events (Addresses CBO-01 to CBO-05)
Tasks	T6.1 Creation and update of website and social media accounts, preparation of COST reports, dissemination of conferences' presentations, preparation and dissemination of peer-reviewed publications. T6.2 Organization of research, educational, exchange of knowledge, technical experience, and mobility eve.
WG-Activities	• Supervision and execution of social network activities (regular updates, contributions) • Organize events (WG meetings, Core Group meetings, Thematic workshops, International conferences, Training/Summer School, STSM).

Management: This work plan will be managed according to the "rules and procedures for implementing COST Actions". At the Action's Kick-Off Meeting the Action Chair (AC), Vice-Chair (VC), Grant Holder (GH), Grant Awarding Coordinator, Scientific Communication Manager (SCM), as well as Working Groups (WG) leaders and co-leaders will be elected by a majority vote. Balance with respect to gender and nationality will be respected and participation of Early Career Investigators (ECI) (at least 25% of WG leaders or co-leaders) and participants from Inclusiveness Target Countries (ITC) (at least 25% of WG leaders or co-leaders) will be taken into account when nominating formal positions within the Action. The AC and VC will form a core group (CG) together with GH, Grant Awarding Coordinator, SCM, WG leaders and co-leaders. The MC will meet at least 1 time a year in order to, scientifically, administratively and financially oversee and manage the Action, ensuring that outcomes are delivered in due time and within the budget. The CG will meet at least 2 times a year, as far as possible jointly with the MC annual meeting and in-between times by videoconferences. The SC will also ensure collaboration and

communication a cross WGs and prepare the agenda of the MC meeting and any associated material for decision-making. The CG will be supported by a Secretariat from the Grant Holder Institution.
The core of the COST Action activities will be carried out at the Working Group (WG) level. The WG leaders should preferably originate from different COST countries and will be elected based on background, leadership and COST scheme experience. The WG leader and co-leader will jointly coordinate the activities within the WG, will chair the WG Meetings and will prepare annual progress reports. Participants of the COST Action will take part in WGs according to their field of expertise or interest. The MC of the COST Action will encourage and support close collaboration and communication between all participants, irrespective of their expertise and research interests. The CG, together with MC, will coordinate the work on the crosscutting tasks, e.g. Living documents.
Short-Term Scientific Missions aiming to strengthen the networking among the researchers of the different groups participating in the framework to improve their knowledge and/or gaining access to specific instruments and/or methods that are not available in their own institution. A call for STSMs will be launched twice a year. Short Term Scientific Missions applications will be assessed within 1 month; based on excellence and impact by prioritizing applications from Early Career Investigators and countries that have less capacity in the field of the Action. A Grant Awarding Coordinator will be assigned by the Action's MC at the Kick-Off Meeting.

4.1.2. DESCRIPTION OF DELIVERABLES AND TIMEFRAME

The COST Action is planned for the next four years. Table 1 presents the Action's milestones, deliverables, and timeframe according to planned Activities during the four years.

Table 1. PEN@Hydropower Action milestones, deliverables, and timeframe.

Deliverables (D)	Months
WG1	
D.1.1 Report on generation/accumulation/consumption of electric energy in Europe, future role of hydropower, identification of new requirements on hydropower.	24
D.1.2 Workshop proceedings of discussions with local stakeholder groups on the condition for settlement of the Hydropower as one bedrock of clean and secure electricity for the future.	43
WG2	
D.2.1 Proceedings of multidisciplinary workshops with experts across disciplines like i.e. mechanical engineering, electrical engineering, business, ecology and sustainability, IT, and more.	31
D.2.2 A white paper on innovative concepts and disruptive technologies in hydropower emphasizing digitalization, flexibility, and resilience.	48
WG3	
D.3.1 Report on water-energy nexus, climate change impacts on hydropower and adaption of hydropower to climate changes.	48
WG4	
D.4.1 Report on the role of hydropower in energy transition, requirements on innovations, identification of current policy gaps	24
WG5	
D.5.1 Proceedings, roadmaps as result of WG5 thematic workshops to cooperate among partners and stakeholders with European, national, regional and local hydropower operators.	11, 24, 34, 47
WG6	

D.6.1 Press release at project kick-off meeting to foster acknowledgment within the community and beyond	1
D.6.2 Social media (Facebook, LinkedIn, Twitter) posts to increase awareness among the community, policymakers, and public.	frequency specified in Dissemination plan ($3.2.2)
D.6.3 Setup of a project website keeping the community updated about the latest actions. Further updates are included.	2
D.6.4 Teaching materials from the training schools of the PEN@Hydropower Action publicly available	7, 19, 31, 43
D.6.5 Living document describing in a compendium the legacy of PEN@Hydro COST Action	48
D.6.6 Press release at project end describing the achievements of the PEN@Hydropower Action	48
D.6.7 Dissemination, Communication and Valorisation Strategy of the PEN@Hydropower Action and its regular updates	9

Milestones:
M1 Kick-off meeting in month 1
M2 1st round of CG, RT, WS, TS accomplished after month 7
M3 2nd round of CG, RT, WS, TS accomplished after month 19
M4 3rd round of CG, RT, WS, TS accomplished after month 31
M5 4th round of CG, RT, WS, TS accomplished after month 43

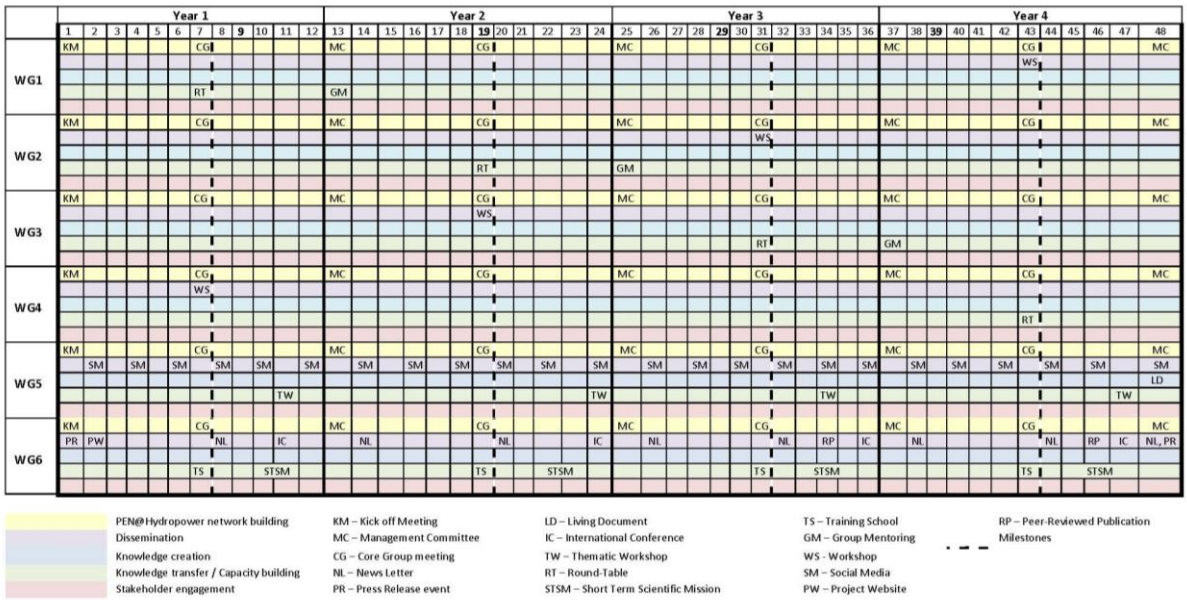
4.1.3. RISK ANALYSIS AND CONTINGENCY PLANS

The risks related to the implementation of this COST Action are identified as follows:

Risk	**Chance**	**Impact**	**Contingency plan**
Low attendance at the Action networking activities	Medium	High	Delegation of responsibilities to collaborating groups of different Action Members in order to enhance commitment among them. The dissemination plan will be tuned according to the feedback of each activity, and certain actions will be taken to address the specific needs, and hence to increase the engagement of the various target groups.
Incapability to involve a wider audience in WGs activities	Medium	High	The partners have recognised expertise in the field and are involved in networks that allow raising the interest of experts and professionals, outside the initial COST network. They will take certain actions (direct communication, contact and invitation through e-mail and social networks, etc.) in order to increase the audience and participation in the various COST networking activities.
Dropout of Network Proposers	Low	Medium	The network contains the critical mass and expertise, which will allow swift placement of substitutes for those who withdraw their participation. Moreover, new potential participants will be continuously contacted to enrich the WGs and increase their members.

Proposers underperform or deliverables delay	Low	Medium	The Management Committee oversees the progress of WGs for timely delivery. As a result, potential delays or sub-quality work can be detected and addressed in advance. If it becomes apparent that the impact is considerable, additional support will be provided to the WG in concern by members of other WGs, based on MC decisions
Research challenges are not adequately addressed	Low	Medium	The Network of Proposers for this Action are highly experienced in their respective fields. The progress of all WGs will be continuously monitored and their outputs will be reviewed internally before dissemination. If it becomes apparent that the impact is significant, early remedial actions will be taken, including reallocation of some tasks, and synergy and cooperation of members of different WGs
Lack of research resources limiting the achievement of the objectives.	Low	Medium	While networking and dissemination is mostly not covered, many investigators receive funding through their institution or have access to national grants for research activities, and they will use such resources if needed.
Non-compliance with funding conditions	Low	Low	The Management Committee will ensure that the Grant Holder follows best practices on budget management. Misuse of the allocated funds or non-fulfilment of the Grant Holder's obligations will automatically lead to the replacement of the Grant Holder

4.1.4. GANTT DIAGRAM



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