SMB/6120/R

STRATEGIC BUSINESS PLAN (SBP)

IEC/TC or SC	Secretariat	Date
4	Canada	Dec 2016

Please ensure this form is annexed to the Report to the Standardization Management Board if it has been prepared during a meeting, or sent to the Central Office promptly after its contents have been agreed by the committee.

Title of TC

Hydraulic Turbines

A Background

TC 4 is responsible for the preparation, periodic review and updating of standards and technical reports covering the design, manufacturing and rehabilitation, commissioning, installation, testing, operation and maintenance of hydraulic machines including turbines, storage pumps and pump turbines as well as related equipment associated with hydropower development. Equipment not part of dam installations and tidal barrage are covered by TC 114 Marine Energy – Wave, tidal and other water current converters.

TC 4 is in charge of twenty six (26) main Standards and Guides (some are additionally available in several languages), either published or being developed. Twelve (12) different Working Groups and Maintenance Teams are currently active in the development of new standards and maintenance of existing standards.

TC4 maintains liaisons with other TC's, ISO, ASME and IEEE regarding Vibrations, Large Flow Measurement, Monitoring & Control and Marine Energies, and monitors activities with other Renewable Energy groups..

Thirteen (13) of the twenty (20) "P" countries participated in the Chengdu Plenary Meeting held October 18-20, 2016, mobilizing the efforts of some 50 active members present from around the world, who collaborated in the update of this business plan.

Please note that an additional fifteen (15) Observer countries are formally registered for TC 4 activities.

As mentioned by the different delegations present at the Plenary, there is a great interest for the publication of IEC TC4 papers in the different Hydro professional journals and/or conferences, with the presentation of the results of our works, in order to provide adequate information to the different customers, consultants and manufacturers around the world. The central office committed its support through their representative Mr. Jacquemart, at the Chengdu meeting.

B Business Environment

B.1 General

Hydropower is currently the most common form of renewable energy and plays an essential part in global power generation. It is a proven and innovative technology based upon many years of experience and expertise.

According to the World Energy Council, Hydro power provides a significant amount of energy throughout the world and is present in more than 100 countries, contributing approximately 15% of the global electricity production. The top 5 largest markets for hydro power in terms of capacity are Brazil, Canada, China, Russia and the United States of America. China significantly exceeds the others, representing 24% of global installed capacity. In several other countries, hydro power accounts for over 50% of all electricity generation, including Iceland, Nepal and Mozambique for example.

The 2016 IRENA statistics report shows that international hydroelectric production is in constant growth, 2.9% in 2014, 29% within the last 8 years, for a world total of 4019 TWh, two thirds of this growth pertaining to the People Republic of China, which in 2014 reached 25% of the world net total.

In the meantime, world hydro capacity reached 1207 TW, a growth of 35% since 2006, 27% of which being installed in China and roughly 17% each in Europe and North-America.

During 2012, an estimated 27–30GW of new hydro power and 2–3GW of pumped storage capacity was commissioned. Over the past two decades the total global installed hydro power capacity has increased by 55%, while the actual generation by 21%.

According to IHA, following a year of significant hydropower development, in 2015, 33.7 GW of new capacity was installed, including 2.5 GW pumped storage, bringing total hydropower capacity to 1212 GW worldwide.

Hydropower is also regaining its status of green energy after more than one decade of disparagement and disinformation. The Word Bank recently declared "hydropower now is viewed as an integral factor in addressing energy security, climate change, water security, and regional cooperation".

Regarding Greenhouse Gas generation, reservoirs in temperate and boreal regions are not responsible for more equivalent carbon emission per kWh of generation than wind or nuclear power. Greenhouse Gas emission per kWh is limited to few per cent of emissions from fossil fuel generating stations. In rain forest regions, it remains well below any of the fossil fuel emissions (less than natural gas and 1/3 to 1/5 of most existing technologies), the smaller the reservoir being the better.

The years 1960-1980 were the golden age of hydro development leading today to a high potential for refurbishment projects.

Greater implementation of intermittent types of energies, mainly wind and solar, necessitate greater requirements for grid stability. Benefiting from both Large and Small hydropower, energy storage and pump turbines enable the electricity grid to cope with random disturbances induced by all other renewable energies, existing and emerging.

Hydraulic turbines have the particularity of not being individually designed in large quantities; they are always unique designs for specific given hydraulic sites. Exceptionally for low head applications and large flows, there are plants with up to twenty identical units.

Pump Storage is nowadays, besides large dam reservoir plants, the only large scale technically and economically feasible storage technology available, capable of providing a number of electric grid services.

B.2 Market demand

The IEA's forecasts of hydropower production range from 5,478 to 6,394 TWh globally in 2035.

Significant low-cost hydro potential still remains to be exploited in many developing and emerging countries in particular Asia, South America and Africa, the latest 2 being other significant regions of hydropower development and emerging and developing countries building large projects will drive most of the growth in hydroelectricity generation in the future years.

The latest estimates of hydropower's technical potential are, in terms of generation capacity (i.e. excluding pumped storage), around 4,400 GW worldwide, of which 1,100 GW have been installed. Hydroelectricity generation in 2013 was 3,800 TWh , against a technical potential of 15,800 TWh

Furthermore, In all, a quarter of the world's technical hydropower potential has been exploited., 23% of reservoirs worldwide in the range 100 to 1,000 billion m3 have not been equipped with hydropower generation capability [ICOLD 2007]. They are used exclusively for other purposes (e.g. irrigation, flood control, navigation and urban water supply). These dams all represent potential that may be easy to exploit without or with minimal impact to their primary purpose.

Decommissioning of old polluting thermal plants and of aging nuclear power plants, the complete phase-out of nuclear energy in some countries, as well as the world difficulty in reducing its energy consumption should put a logical pressure on the increased demand for very valuable hydroelectric projects, the world potential being estimated between one and two million MW.

The expansion in recent years of the other renewable but intermittent energy, being solar or wind, changed drastically the energy market. Being intermittent they rely heavily on a second stable energy source and Hydropower, through its large reservoirs or through pump storage plants, is one of the preferred complementary source. With these changes come a need for a variety of ancillary services to stabilize the grid and balance the power. The use of reservoirs as storage are in an energy scale that is not comparable with e.g. batteries. In many reviews pump storage may be mentioned as a storage alternative but not hydro storage in rivers, de-accelerating /accelerating flow using reservoirs. The latter is in major power systems 10-100 times larger in energy storage volume than pump storage. For example in Europe, hydro storage is around 200TWh compared to 2-3 TWh.,in pump storage.

The current mixed situation in Europe, due to the large increase of intermittent renewable sources like wind power and photovoltaic solar power: even if there are interesting long-term perspectives for the development of hydro, due to the rising needs for power reserves and inertia which can be provided by the HPP for the grid frequency control, the current low prices on the European electricity market, and the uncertainties about the future market model, prevent the large utilities from investing at the moment.

With greater globalization of manufacturing facilities including new locations requires a better integration to globally recognized and internationally approved standards.

Extending equipment availability, increased performance and reliability as expected from long running hydro production units, necessitate increasing rehabilitation expertise and efforts to further extend the life of their valuable energy contributions, contributing to increased grid stability and revenue generation capabilities.

Loss of expertise from retiring technical experts and with lower numbers of younger colleagues integrating this area of specialized technology, can be partly compensated by technical experience documented in these technical Standards.

B.3 Trends in technology

The development of computational tools during the last fifteen years has brought hydraulic turbines to a level of quality and reliability which might seem difficult to improve, most new units being able to extract 95% of the hydraulic energy they receive in their most frequent operating zones. The challenge is to still improve the tools in order to calculate dynamic load for example and find ways to predict the remaining life expectancy.

As mentioned before, because of its flexibility, hydro is particularly well suited to be a major contributor to this increase of demand for grid and power regulation, as well as ancillary service like black start capability, frequency stabilization through the machine's inertia, reactive power control, voltage control, balancing power, frequent starts and stops, part load operation, spinning reserve, faster response. Black start capability, frequency stabilization through the machine's inertia, reactive power control, voltage control, balancing power . frequent starts and stops, part load operation spinning reserve, faster response,

In addition to the hydraulic aspects, the mechanical aspects become more and more important, in relationship with their much more starts/stops, their greater range of operation, and the more frequent large load variations due to the provision of reserves for the grid frequency control.

Materials and fabrication tools will continue to evolve, including increased used of industrial robots.

Fatigue computations and sophisticated commissioning tests can aim to space out major overhauls. Planned and unplanned outages are expected to remain in the region of one per cent, in spite of daily starts and stops made necessary to accommodate the growing fluctuations of the grids.

Promote and include in standard new technologies such as variable speed (doubly fed asynchronous machines and full frequency converters with synchronous machines) as well as hydraulic short circuit operation of ternary units enabling hydropower plants to provide high quality control services for primary and secondary control (and also for ternary control) needed for a better integration of new renewable energies.

Surprisingly, both these extreme performances and reliability can always be improved by tenths of a percent, precisely because of the exceptional longevity of hydropower installations, high specific energy and the excellent return on investment they authorize. Research and development is needed even more for the megaprojects being now developed or planned.

As outlined in the HEA roadmap, bigger units are intrinsically more efficient. A machine with a 10 m runner, such as the one installed at XiangJiaBa in China, is 0.1% more efficient than a machine with the design scaled down to 8 m, because in larger machines, flow friction losses are relatively smaller (higher Reynold's number). On a 800 MW turbine, this could equate to the annual generation of a 2-MW onshore wind turbine. Economies of scale are achieved in the manufacture of larger units.

Extension of plant life time remain a major issue with the aging of a large part of the installed hydro generating plants. Better monitoring and diagnosis equipment and tools, should help to optimize operations and timely maintenance.

Erosion remains a concern in many areas and research on better materials and coatings is constant.

B.4 Market trends

Since electric energy demand is still growing, the market is active and will support the existing hydroelectric industry for many decades, either for new projects or rehabilitation and upgrades.

Industry concentration can be considered completed and the world financial crisis should not compromise the trends for a better cleaner world. Electrification of domestic and public transportation is part of this trend and will require flexible and predictable sources of energy.

In their Hydropower status report, IHA states that financial instruments are making hydropower investments more attractive through the involvement of more multi-lateral agency, like the World Bank or IFCC,

The marketing of green bonds and carbon credits contributes also to render hydropower financially more attractive, as does the growth of the need for ancillary services, like frequency response, reactive power, inertia and fast response. Hydropower is well placed to provide these services for good revenues and is the only commercially viable and dispatchable renewable.

However, cheap oil and gas, mainly shale gas, may hamper somehow the development of large hydropower as might do the development of large storage other than pump-storage (High capacity battery or compressed air storage).

B.5 Ecological environment

Large hydropower remains the best legacy to future generations with a return on investment in terms of produced and invested energy ratio over a life cycle of 200 to 300 as compared to an optimistic 30 for windpower; 15 for nuclear; and 3 to 5 for plantation biomass, solar photovoltaic and combined cycle natural gas; and even less for most fossil fuels.

As outlined by IHA in their 2016 Hydropower status report, new international policy and agreements, like the UN Sustainable Development goals adopted in September 2015, will drive further hydropower growth. Furthermore, climate aspects will increasingly influence project design

Carefully planned, safely engineered, developed by socially responsible communities, Hydroelectricity is recovering the aura it had before the public developed an exaggerated infatuation for new renewable sources of energy whose performances and real costs now appear less attractive.

Electricity is strongly linked to development and communities who have access to hydraulic energy must be able to take advantage of it, so reducing wood burning, erosion and floods, and getting access to irrigation, local food supply, drinking water and more attractive socially healthy communities.

Increasing demand for fish friendly turbines in US and many other parts of the world.

Turbine designs that are capable of producing minimum continuous discharges to support fisheries and recreation downstream of a hydro plant. For an existing plant, these minimum continuous discharges are often much lower than the original design flows, so this topic also fits in the discussion of extremely flexible operation.

Turbine designs that mitigate negative impacts on water quality such as oil-free hubs and turbines that increase dissolved oxygen levels in the turbine discharges through aeration (during periods when the upper reservoir stratifies in the summer months of warmer climates).

C System approach aspects

Flexible operation -- Frequency regulation and grid codes: Can we in liason with SC8A predict future grid variations when more and more renewables coming into the system, and thus give an input how frequency regulated turbines will/needs to respond => wear and tear?

SC 8 A Scope -- To prepare and coordinate, in co-operation with other TC/SCs, the development of international standards and other deliverables for grid integration of variable power generation from renewables such as PV and wind energy with emphasis on overall system aspects of electricity supply systems (grids) as defined in TC 8 scope, but not covering issues usually covered by regulation such as renewable policies. SC 8A focuses on the impact of a high percentage of renewables connected to the grid, considering that their variability and predictability impact the functioning of the whole electricity grid. It covers grid integration standards for renewable energy, aggregating contributions of all grid users and prescribing interaction modes between the grid and power plants. This includes requirements for interconnection and related grid compliance tests, as well as standards or best practice documents for planning, modeling, forecasting, assessment, control and protection, scheduling and dispatching of renewables with a grid level perspective.

Note 1: SC 8A deals with the grid level requirements enabling secure, non-discriminatory and cost effective operation of electricity supply systems with a significant share of renewable generation and cooperates with TC 82, TC 88, TC 95, TC 114, TC 115, TC 117, TC 120 and other product committees to ensure technical feasibility and verification of the implementation of the grid level requirements.

Note 2: SC 8A coordinates with TC 8 which covers standards related to Distributed Energy Resources (e.g. interconnection with the grid, design and operation of micro grids).

Increasing role of TC8 (Systems aspects for electrical energy supply) in the Renewable Energy sectors, recommending to have a Liaison with both TC8 and TC88 (Wind energy generation systems)

The hydroelectric science is already supported by a century of research, publications and tests. The future will combine this valuable know-how with new technologies.

Industries are moving towards the major markets, mainly the Asia-Pacific area, and the tradition of excellence and reliability of the hydroelectric industry has to survive such reorganizations.

International standards, based on the best practices, are the answer to this necessity of preserving and improving the traditional reliability of equipment, some of which are still in as-new condition in spite of being nearly a century old.

D Objectives and strategies (3 to 5 years)

The main objective is to be recognized as the leader in the development of turbine standards by elaborating and maintaining standards of optimal performance and improved reliability in order to ensure hydro remains a competitive renewable energy source.

To do this the committee has to:

- ensure participation and representation of a wide audience of all sectors of industry and to make efforts to expand it, by the recruitment of new member to renew the aging turbine expert community;

- continue the efforts of involving new participating country

- adapt the standards to the new technology progress and regulatory conformity

- provide leadership in development of appropriate and recognized standards

- improve promotion within the industry, also increasing information from manufacturers and academia

All in synergy with ISO & IEEE related standards

E Action plan

The involvement of China in most working groups of the IEC-TC4 is now a fact and the expertise gained through the large Chinese Hydroelectric Projects is particularly important. Efforts are being made to involve major South-American countries as Participating Countries, bearing in mind the activity in, and considerable potential of these zones. In 2014 the joining of Brazil is a first step towards sharing their know-how and expertise with the various working groups and hence improving the standards prepared by the committee. An other region to prospect is Africa where an increasing number of large hydroelectric schemes are planned.

The USA is a recent example of increased governmental encouragement of hydro production wishing to vastly increase additional hydroelectric activities in that country. They quoting that their industry could add 70,000 MW of capacity by installing more efficient turbines at existing dams, increasing the use of pumped-storage projects, and encouraging the use of run-of -the-river turbines. The great energy potential is noted, with only some 3% of that country's 82,000 dams presently used for electricity generation. Efforts have will be made to get a greater involvement of US technical experts, which currently seem underrepresented.

More specifically standards will be developed to include:

• Model step-up and homology to incorporate available manufacturing technologies and the influence of roughness

• Modernization of discharge measurement methods at site

• Prediction of hydro abrasive erosion resistance and definition of measures to improve the erosion resistance.

• Up to date power plant automation and turbine governing systems specifications and testing

• Up to date commissioning guidelines;

• Development of internationally recognized installation rules;

• Establishment of unit vibration limits;

• Include a robust design approach to the enhance the reliability of hydraulic turbo-machinery;

• Erection tolerances need to be standardized, preferably in conjunction with TC2, since the Industry has now largely integrated hydraulic and electrical machinery supplies and installation;

• Pursue ongoing discussions on the use of hydroelectric generating equipment for stabilization of power networks in the mix with all other renewable energies, existing and emerging, and of hydro's unique storage capabilities for power generation.

• Continue the existing liaisons with ISO, IEEE and follow-up the other hydropower related organizations; evaluate the possibility of liaison with TC8 for the systems aspects for electrical supply.

Finally to promote the work of the committee, efforts will be made to:

• Possibly publish papers while participating in Conferences promoting Standards.

• Increase presence in the General Market to inform and promote technology changes and get more involved in informing of changes in Engineering contributing to improved Environmental concerns, with mention of addressing the Paris Climate Agreement

- Present summary of new IEC publications and explanation of the main changes by the experts on behalf of IEC at international events like Hydro and Hydrovision conferences.

- Seek increased IEC Central Office aid for publishing articles (including IEC e-tech, etc) providing brochures, write-ups and promotion

F Useful links to IEC web site

TC home page giving access to Membership, TC/SC Officers, Scope, Liaisons, WG/MT/PT structure, Publications issued and Work and Maintenance Programmes and similar information for SCs, if any.

Name or signature of the secretary

Robert Arseneault