world hydropower congress

Better **hydro**
in an interconnected world

9–11 May 2017

Addis Ababa

The report

Organising partners

iha international hydropower association

Global Energy Interconnection Development and Cooperation Organization
全球能源互联网发展合作组织

African Union Commission

ECA

WORLD BANK GROUP

Host

Government of Ethiopia

In this report

Defining the future of hydropower

By Richard M. Taylor, CEO
International Hydropower Association

Introduction

Every two years, the World Hydropower Congress of the International Hydropower Association brings together leading decision-makers, innovators and experts to share experience, guide policies and develop strategies to improve performance in the sector.

Capacity-building and stakeholder dialogue are at the core of this high-level event, which contributes to advancing our common vision: a world where water and energy services are delivered to all in a sustainable way.

This report provides an overview of the discussions that took place at the 2017 World Hydropower Congress in Addis Ababa, Ethiopia, under the auspices of the United Nations Economic Commission for Africa and the African Union Commission. It includes the speeches that were delivered in the high-level segments of the conference, as well as summaries of the presentations and exchanges that happened during the technical and business segments.

Organising partners of the event included: the International Hydropower Association (IHA), the Global Energy Interconnection Development and Cooperation Organisation (GEIDCO), the African Union Commission (AUC), the United Nations Economic Commission for Africa (UNECA), the World Bank Group and the Government of Ethiopia (GoE).

This report gives us an opportunity to extend our warm thanks to the above, and to the additional fifty organisations that took part in shaping and supporting the programme, which extended over five days.

Our session co-convenors included a range of institutions with internationally acclaimed expertise, who helped broaden the perspectives in each of the session. These included organisations from the United Nations system, financial institutions, international organisations, non-governmental organisations, governmental and intergovernmental agencies, as well as research institutes. In total, thirty-two sessions, workshops, lectures and high-level meetings were organised to address the theme of the congress: Better hydro in an interconnected world.

This theme had a dual purpose: it served to highlight the value of partnership and collaboration in improving the contribution of hydropower to society, but it also signalled a new reality, as policies and strategies can no longer afford to focus on a single technology, and development proceed on a project-by-project basis. The congress emphasised the need for systemic approaches in tackling today's energy, water and climate challenges.

Among the topics discussed, smart energy systems and project preparation stood out as cross-cutting themes that provided direction for future action. With the support of GEIDCO, the congress outlined a vision for a resilient, clean and decentralised energy grid, where hydropower would play a key supporting and enabling role.

The African Union Commission and the UN Economic Commission for Africa emphasised the need for better regional planning and project preparation, the definition and implementation of which appeared as a golden thread throughout the programme. With appropriate environmental and social safeguards, improved project preparation was seen as a pathway towards delivering better outcomes for governments, investors and society in general.

As a unique platform for collaboration and exchanges, the congress brings together delegates from all countries and regions where hydropower is on the agenda. In 2017, more than 630 delegates from 60 countries participated in the discussions.

The congress concluded on commitments from our partners to carry the torch of sustainable hydropower in their activities, as civil society, institutional and business players. All put a particular emphasis on supporting an enabling framework for hydropower in Africa, a first-time host of the event.

"If you want to go fast, go alone; if you want to go far, go together."

New partnerships were born, recent initiatives and practical tools were presented in Addis; but we expect to only be able to appreciate the full impact of the 2017 congress over time, because of the journey that we commit to take, from shared objectives to recommendation and implementation. "If you want to go fast, go alone; if you want to go far, go together", the African proverb, repeated in Addis, captures the essence of the journey we embark on.

A renewed commitment to the spirit of the congress emerged over the course of the event. With partners and participants, we understand the utmost importance of keeping the doors open for dialogue, without which no progress is possible.

The next World Hydropower Congress will take place in Paris in May 2019. As we look to strengthen the contribution of sustainable hydropower to the Paris Agreement and to the Sustainable Development Goals, we hope to bring forward the progress of our enriching experience in Addis.

Meet the organisations behind the congress

Our partners are organisations active in the climate, water and energy arena, and their contribution helps to enrich the programme of the event.

Acknowledgements

Organising partners
African Development Bank (AfDB)
African Union Commission (AUC)
Global Energy Interconnection Development and Cooperation Organization (GEIDCO)
International Hydropower Association (IHA)
United Nations Economic Commission for Africa (ECA)
World Bank Group (WBG)

Host and supporting governments
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Government of Switzerland
Agency for the Development and Promotion of Grand Inga

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Shandong Electrical Engineering and Equipment Group Co. Ltd.
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Partners and co-convenors
African Climate Policy Centre (ACPC)
African Energy Commission (AFREC)
African Power Utility Association (APUA)
Climate Bonds Initiative (CBI)
Climate Policy Initiative (CPI)
Conservation International
China Society for Hydropower Engineering (CSHE)
European Bank for Reconstruction and Development
Institut de la Francophonie pour le Développement Durable (IFDD)
Infrastructure Consortium for Africa (ICA)
International Energy Agency (IEA)
Interamerican Investment Corporation (IIC)
International Renewable Energy Agency (IRENA)
International Union for the Conservation of Nature (IUCN)
New Partnership for Africa's Development (NEPAD)
Red Cross/Red Crescent Climate Centre
Southern African Development Community (SADC)
Sustainable Energy for All (SE4All)
Transparency International
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Speeches and statements

International decision-makers and thought-leaders from industry, government, finance and civil society shared their visions to achieve the Sustainable Development Goals in an interconnected world

Achieving more through cooperation

Statement by

Ken **Adams**

President, International Hydropower Association

// Hydropower is not done in isolation. This is a fact well known to any developer in the world.

This is also the premise upon which the International Hydropower Association was founded, twenty-two years ago.

The idea that, to be successful, a project must involve a wide consultation, is a very powerful one.

Our project, as an association, is to advance sustainable hydropower. Our journey began 22 years ago, hand in hand with the hydrological programme of UNESCO. Our work has always been grounded in science and knowledge, and this original partnership established the spirit in which we would carry out our work.

We would not have progressed in our journey without the knowledge and support of our members, active in more than 100 countries, as well as our diverse community of partners.

In 2017, more than 50 organisations have decided to support the World Hydropower Congress, and help define "better hydro in an interconnected world". Many of whom have worked alongside us for a number of years.

I want to take this opportunity to acknowledge our organising partners: the African Union Commission, the United Nations Economic Commission for Africa, the African Development Bank, the World Bank Group, and the Global Energy Interconnection Development and Cooperation Organization.

I also want to thank our sponsors, and in particular China Three Gorges, China Electricity Power Equipment and Technology, GE, PowerChina/Sinohydro, Sarawak Energy, State Grid Xin Yuan and The Nature Conservancy.

As we prepared for this congress, we learned a lot and have no doubt achieved in making this programme one of the most interesting and relevant to date.

Reflecting on the history of IHA, it is clear that achieving sustainable development goals will not be possible without

breaking barriers and widening the scope of collaboration between all of our institutions.

We must widen our collaboration because we must embrace the fact that not one single technology will, alone, resolve the tremendous energy challenges of this century.

Without more generation coming onto the grid, hydropower will not be able to play its role as a flexible, cost-efficient and renewable energy source. Most importantly, without more generation, the under-recognised value of energy storage that hydropower can provide will be lost.

We must widen our collaboration, because, over the next decade, governments, businesses and civil society, will be pressed to be more creative, more effective and work more closely together to design new mechanisms to meet the Sustainable Development Goals and deliver on the Paris Agreement targets.

This is the sense of our efforts to open the dialogue around hydropower project preparation. We believe that the obstacle to sustainable hydropower development, is not a lack of money, but a lack of certainty for private investors.

This is also why we have supported the international collaborative efforts to determine the carbon footprint of hydropower, or improve understanding of climate change resilience.

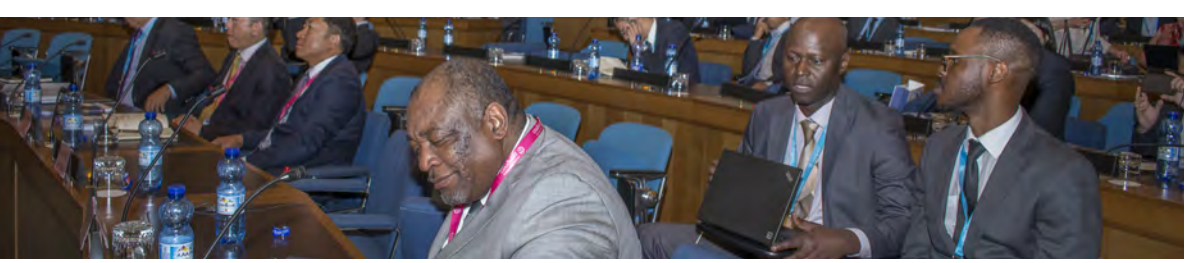
This is why, finally, we are starting a closer dialogue around global energy interconnection with GEIDCO. A new impulse towards the creation of infrastructure frameworks to enable projects to happen is much welcome.

All these aspects, we believe, have the potential to unlock hydropower development around the world and contribute to the delivery of the Sustainable Development Goals.

In this process, not one single institution can carry the weight of delivering on the formidable challenges ahead.

With our own remit, we will continue to act as a convenor and a receptacle for knowledge on good practices. We will also seek to be an incubator for progressive ideas in the sector.

Our strength is to nourish the dialogue between our association and other institutions, governments, businesses and civil society. We invite our partners to formalise commitments that can be reviewed in two years' time and we look forward to playing a role in solving the complex challenges of this time ■




9-11 May 2017
EXIT
EXIT

Guiding principles for decision-makers

Remarks by

Amani **Abou Zeid**

African Union Commissioner for Infrastructure and Energy

// The African Union Commission has been committed for many years to promoting sustainable hydropower development on the continent.

It has partnered with many international organizations and development partners on sustainable energy development. In this regard, many initiatives on hydropower development have been undertaken and new ones are being launched. By hosting the Hydropower Congress in Addis Ababa, we expect to raise more interest among developers and financiers to invest in Africa's hydropower development.

Africa is the fastest developing continent. This development requires stable and reliable energy to power it. Africa does not have to follow the path of the developed world, where such development resulted in extensive pollution, which we are still struggling with today. Africa is going to leapfrog past these experiences by embracing renewable energy, sustainable and inclusive development. We are going to harness the hydropower resources available in Africa, together with other renewable solutions, to meet the energy needs for developing the continent.

When we look around Africa, hydropower electricity provided the building blocks of the electricity sector in nearly all regions. Whether you think of Aswan in the north, or Akosombo in the west, Zambezi in the south, or Owen Falls Dam in East Africa – Africa's electricity sector was birthed in hydropower, which also served as nodes for the first interconnection projects. Enormous potential still remains in these basins and I am pleased to note that Africa is awakening once again with the development of hydropower.

"What is different about this re-awakening? This time the development of hydropower is much more inclusive."

What is different about this re-awakening? This time the development of hydropower is much more inclusive. It looks beyond merely electricity generation and seeks to address the pressing social needs of job creation for the youth, empowerment of women and climate change challenges.

Under the Programme for Infrastructure Development in Africa (PIDA), the African Union Commission (AUC) has a number of flagship projects of which Inga III is a key priority. The AUC is working with the Democratic Republic of Congo to unlock the bottlenecks that kept this sleeping giant from being developed. Now there is light at the end of the tunnel.

The AUC is also working with regional economic communities and development partners to promote the development of small hydropower resources scattered throughout the continent. The development of small hydropower projects in Africa has direct impacts in enhancing access and job creation for Africa's youth, especially those in rural areas.

I am happy in my capacity as the new African Union Commissioner for Infrastructure and Energy that the Hydropower Consultative Council composed of highly experienced personalities provides a forum to share regional perspectives, knowledge and expertise, and practical experience in developing sustainable hydropower projects, so as to guide the World Hydropower Congress' key objectives and priorities for action.

Hydropower is a proven and reliable technology that has undoubtedly played a major role in the world's development. However, hydropower is threatened by climate change which we must all be concerned about. I, therefore, call upon the Consultative Council to be at the forefront in the fight against climate change for the sake of hydropower development in the world.

"I would like to add my voice and encourage the idea of establishing a hydropower preparation support facility."

A particular focus should be on how better hydro could be delivered, particularly in Africa. I would like to add my voice and encourage the idea of establishing a hydropower preparation support facility designed to spearhead optimal development of already identified priority hydropower projects, within PIDA-PAP and AU Agenda 2063 flagship projects or other initiatives.

I would also like to see more concrete commitments from our development and private sector partners, those already working with us and new ones wishing to join efforts with our national power utilities, regional power pools, regional economic communities and river basin organisations.

I do recognise that, in many African countries, more still needs to be done on removing barriers to private sector engagement.

Given the existence of many regional and continental initiatives in Africa in the energy sector, and expecting new initiatives to come, the AUC is committed to strengthening effective coordination and harmonisation of these initiatives as well as open dialogue with all stakeholders, in close cooperation with all partners ■

The twin challenges of development and climate change

Speech by

Thomas Kwesi **Quartey**

Deputy Chairperson,
African Union Commission

// The African Union Commission is proud to be part of the organisers and co-hosts of this important and global event.

I would like to, first of all, commend and also express my gratitude to the Government of Ethiopia for its valuable support and cooperation, and for hosting this important congress in this beautiful and cultural city.

I would also like to commend the efforts of the International Hydropower Association for hosting this important event in Africa and for championing the global discussions and sharing of experiences in the development of hydropower.

As we are all aware, access to modern and sustainable energy services is crucial to achieving sustainable, transformative and inclusive development. The current global discussions and development frameworks including the United Nations Sustainable Development Goals and the Paris Agreement, have all identified that access to sustainable energy serves as a catalyst to promoting economic, social and human development.

The Agenda 2063 of the African Union clearly calls for ensuring efficient, reliable, modern and sustainable energy access for all Africans, which will be crucial to achieving our vision of "an integrated, prosperous and peaceful Africa, driven by its own citizens and representing a dynamic force in the global arena"

The twin challenges of development and climate change means that there must be a global shift towards low carbon and climate-resilient development. The deployment and expansion of renewable energy provides one of the most effective strategies to simultaneously promote development, sustainable energy access, energy security as well as climate change mitigation at the global, continental and regional levels.

"Amongst all the renewable energy resources, hydropower is the most cost-effective and technologically mature power generation technology."

Amongst all the renewable energy resources, hydropower is the most cost-effective and technologically matured power generation technology. For Africa, it provides significant opportunities.

First, the abundance of this resource on the continent and the maturity of the technology indicates its crucial role in expanding electricity access, which currently stands at 31 per cent in sub-Saharan Africa. The continent accounts for about 12 per cent of the world's technically feasible hydropower potential, with potential to generate over 1,800 TWh of electricity from this resource. Currently, less than 10 per cent of the hydropower potential in Africa is exploited. Thus this resource provides ample opportunities for Africa to develop both large and small-scale energy infrastructure at the regional, national and local levels.

Hydropower could also be used to decarbonise the future energy mix. Currently, fossil fuels account for over 80 per cent of the electricity generation mix on the continent, while hydropower accounts for about 15 per cent. Developing hydropower will enable Africa to meet its climate change mitigation and low-carbon development objectives.

Hydropower infrastructure also provides opportunities for Africa to address other pressing development challenges, including: water supply, irrigation for agricultural development, as well as flood and drought control.

Hydropower will also play a significant role in regional integration. Developing this resource at continental and regional levels will enhance economic cooperation and trade as well as create integrated markets amongst member states.

As the African Union Commission (AUC), our role is to develop and coordinate policies and mobilise resources for the development of the energy sector. The AUC already strongly recognises hydropower development in Africa as one of the major means to expand and improve access to cost-effective electricity on the continent as well as enhancing regional integration.

The Programme for Infrastructure Development in Africa (PIDA) is one of our initiatives dedicated to facilitating continental integration through improved regional infrastructure and the creation of energy markets with a view to fostering inter-regional energy trade and cooperation. The PIDA programme already includes nine hydropower projects to be developed in the short-term and an additional 20 hydropower projects to be developed in the long-term, adding a total of 54 GW of hydropower capacity to the African grid by 2040. We are actively working on regional harmonisation of energy policies, stakeholder engagement and mobilisation of financial and technical resources in order to ensure the continued success of these projects.

"We are eager to learn from the experiences of other continents and countries in addressing issues in hydropower development."

The African Union is also working with the Government of the Democratic Republic of Congo (DRC) to develop the Inga hydropower project, as one of its flagship programmes under the AU Agenda 2063. As you are aware, the DRC alone accounts for about 42 per cent of the continent's hydropower potential. Thus active engagement with

the government of DRC will be key to optimal utilisation of this potential.

There is a great need for us to engage with specialised institutions, such as the International Hydropower Association, in order to benefit from a range of expertise and their networks of experts and private sector players. We are also eager to learn from the experiences of other continents and countries in addressing several issues in hydropower development including the water-energy nexus, social issues associated with resettlement, financial structuring, project development as well as climate resilience issues.

I would like to conclude by stressing once again that hydropower development is integral to the current and future plans of regional infrastructure development in Africa. For Africa, the most important barriers to address in implementing our hydropower development plans include the financial, technical and institutional barriers.

We therefore call upon the financial institutions, the private and public sectors, civil society organisations and research institutions, amongst others, from all parts of the world to join us in our endeavours ■

Setting the course for the global energy interconnection

Speech by

Liu Zhenya

Chairman, Global Energy Interconnection Development and Cooperation Organisation

// On September 26 2015, at the UN Sustainable Development Summit, Chinese President Xi Jinping proposed to establish global energy interconnection, or GEI.

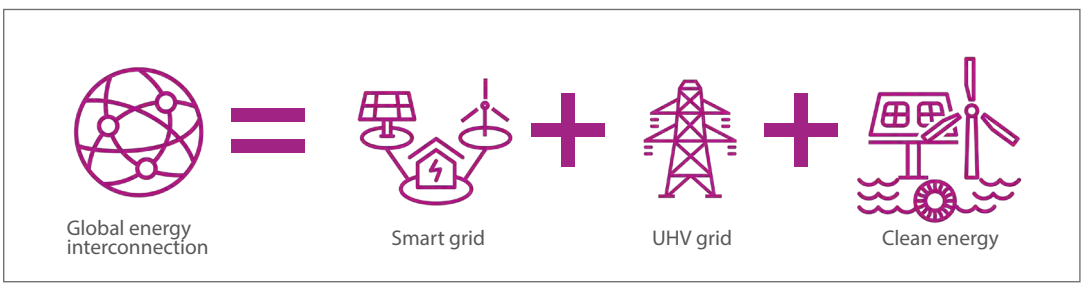
This initiative was intended to meet global power demands with clean and green alternatives. This Chinese solution to global energy transition and connectivity has won widespread praise and a positive response from the international community. I would like to share my ideas from three perspectives in relation to global energy interconnection (GEI) and African energy interconnectivity.

GEI is the inevitable way ahead for the clean and low-carbon energy transition.

"If we develop clean energy at an annual growth rate of 12 per cent, it is expected that by 2050, clean energy will take up 80 per cent of total global energy consumption."

Currently, global energy consumption totals about 20 billion tonnes of standard coal, of which 80 per cent is fossil energy, which brings with it issues like resource constraints, environmental pollution and climate change. It is expected that by 2050, global energy demand will reach 30 billion tons of standard coal with more than 24 billion tons being fossil fuels if the current energy mix is to continue, leading to ecological catastrophes. However, if we develop clean energy at an annual growth rate of 12 per cent, it is expected that by 2050, clean energy will make up 80 per cent of total global energy consumption with power generation from clean sources reaching 66,000 TWh. Thus, carbon emission will be cut substantially and the global average rise in temperature will be limited within 2°C.

Therefore, it is imperative for us to accelerate the green and low-carbon transition. The key to realise that is to bring forward a new energy supply



system prioritised by clean energy development and power supply with large-scale optimal allocation on the GEI platform.

The intention is to realise "two replacements, one increase and one restoration" and forge a green, low-carbon, interconnected energy community co-constructed and shared by the world. Only then can we reshape the course of energy development.

GEI equals "Smart Grid + UHV Grid + Clean Energy"; it is an infrastructure platform on which clean energy can be developed, transmitted and used massively worldwide.

"Two replacements" refers to replacing fossil energy with clean alternatives such as solar, wind and hydro in energy production, and replacing coal, oil and gas with clean electricity from afar in energy consumption.

"One increase" means increasing electrification, bringing up the proportion of electricity in energy consumption while bringing down total consumption on the ground of meeting the energy demand.

"One restoration" is to restore fossil fuel to its basic attribute as an industrial raw material to create even greater value in socio-economic development.

The principle of realising "two replacements" lies within the GEI. We have abundant clean energy resources that are unevenly distributed around the globe. For example, in Africa-Eurasia, 85 per cent of clean resources are concentrated in the energy belt starting from North Africa through Central Asia to Russia and the Far East, which is at 45° angle to the equator. Most resource-rich areas are usually hundreds and even thousands of kilometres away from power loads. These resources need to be transformed into electricity on site to be transmitted over long distances and allocated on a massive scale. Besides, wind and photovoltaic (PV) power generation is intermittent and volatile. Only by integrating them into a vast power grid can they enjoy better development. This determines that the GEI is an inevitable way out for the massive development and use of clean energy and safe, clean and sustainable energy supply.

The conditions to build GEI are there.

Technically, critical technologies like UHV and smart grids have become mature, with new breakthroughs constantly being made. ±1100kV HVDC transmission can run over 6,000 km with a transmission capacity of 15 GW. Now, China has completed six AC and seven DC UHV power transmission projects.

Another two AC and seven DC UHV projects are under construction. The total length of all the above-mentioned UHV transmission lines adds up to 35,000 kilometres, with a transformation capacity of 360 GVA. Economically, clean energy is becoming increasingly cost-efficient. Recently in a number of bid-winning photovoltaic projects in Chile and the United Arab Emirates, the cost plummeted to USD 3 cents per kWh. It is expected that by 2025, wind and PV power generation will become more competitive than fossil fuels.

Politically, the signing of the Paris Agreement and the implementation of UN 2030 Sustainable Development Agenda creates a favorable political environment to foster breakthroughs in GEI.

"We now have 265 members spanning across 22 countries and regions in five continents."

Accelerating GEI has become a global consensus. In March 2016, the Global Energy Interconnection Development and Cooperation Organization (GEIDCO) was established. We now have 265 members spanning across 22 countries and regions in five continents. In the past year, we have made groundbreaking progress in awareness-raising, fundamental research and international organisation, pushing GEI into a new stage of strategy implementation and joint action. We organised and participated in over 30 international conferences and carried out more than 360 publicity events. Friendly partnerships with 130 international organisations, government departments, businesses and academic institutes from 41 countries and regions are now in place. Besides, we are privileged to have support from international organisations such as the United Nations, the World Bank and the International Energy Agency as well as leaders of the United States, Russia and Germany. UN Secretary-General, António Guterres, seconded the inclusion of GEI into the 2030 Sustainable Development Agenda to guide countries' participation in the progress. Maged Abdelaziz, UN Under-Secretary-General and Special Adviser on Africa, spoke highly of GEI for boosting clean energy development and outbound transmission in Africa. He regards it as an effective way to increase power supply in Africa and improve the well-being of African people.

The shaping of GEI can be divided into three interconnection phases: domestic, intracontinental, and intercontinental. By 2050, GEI will come into being. By then, clean energy will be the dominant energy. Meanwhile, carbon emissions can be controlled at half of that in 1990. GEI can link major clean energy bases and power loads together to effectively develop, deploy and use all kinds of centralised and distributed clean energy on a large scale. Substantial interconnection benefits will be generated through differences in time zones, seasons and prices. In this way, we can effectuate "Sustainable Energy for All" and turn the world into a peaceful, harmonious global village with sufficient energy, green lands, and blue skies.

African Energy Interconnection is the key to energy transition and sustainable development in Africa.

Energy is a major issue affecting socio-economic development in Africa. Recent years have witnessed rapid social and economic progress in Africa with

(continued)

an average annual economic growth of 5 per cent. Agenda 2063, a strategy framework set by the African Union, envisages an integrated, prosperous and peaceful Africa. And sustainable energy supply is the be-all and end-all for this grand prospect. However, African energy development still faces many difficulties and challenges.

Firstly, energy and power development seriously lags behind. Currently, per capita energy consumption in Africa only stands at a third of the global average with an installed capacity of 190 GW, less than 3 per cent of the global total. The installed capacity per capita is only 0.15 KW, less than 18 per cent of the global average. Besides, 600 million people, or more than half of the African population, still do not have access to electricity.

Secondly, energy demand is increasing rapidly. Since the beginning of the 21st century, primary energy consumption in Africa has increased from 710 million tons of standard coal to 1,100 million tons, growing at 3.2 per cent every year. Fast-paced industrialisation and electrification on the continent poses huge potential demand for electric power. However, Africa's fossil fuels make up only 5 per cent of the global total, impossible for the continent to meet its own demands.

Thirdly, pollution has become a major problem. At present, 70 per cent of African people still use wood and charcoal as the major energy source in daily life, accounting for 48 per cent of total energy consumption. Fossil fuels make up 36 per cent. They emit a large amount of pollutants and CO_2. Eighty-five per cent of the population live in areas with a concentration of fine particulate matter exceeding the recommended level. Air pollution alone causes several hundred billion US dollars of economic cost.

African energy interconnection is a way forward for energy issues and sustainable development in Africa. The continent is bestowed with abundant, quality clean energy resources that are unevenly distributed. Technically-exploitable hydropower resources in Africa are about 340 GW, with Central Africa, Eastern Africa, Western Africa and Southern Africa taking up 55 per cent, 17 per cent, 9 per cent and 16 per cent of the total. To some extent, hydropower is an important catalyst to develop clean energy in Africa. To be more specific, the potential installed capacity of hydropower in the Grand Inga on the Congo River, the Nile, Niger River and Zambia River has exceeded 40 GW, 45 GW, 16 GW and 15 GW respectively. Technically-exploitable wind power resources stand at about 200 TW, which are mainly distributed in the northern, western and southern coastal areas, accounting for 28 per cent, 36 per cent and 24 per cent of the total on the continent. Technically-exploitable solar power resources are 250 TW, which are mainly distributed in northern, southern and eastern areas, accounting for 18 per cent, 28 per cent and 35 per cent of the total. Annual PV power utilisation in some areas has exceeded 2,500 hours. The receiving solar power per square metre of land equals that of two barrels of crude oil. Currently, clean energy in Africa is underdeveloped with the installed capacity of hydro, wind and solar power standing at only 33 GW, 3.7 GW and 3 GW, accounting for one tenth, two hundred thousandths and one hundred thousandth of the total.

"We can realise cross-border, cross-regional and inter-continental allocation of clean energy and deliver the energy landscape with hydro, wind and solar power complementing each other."

To realise Agenda 2063 and meet the needs for socio-economic development, Africa will need 2,000 TWh and 5,000 TWh of electricity in 2030 and 2050 respectively, or 2.7 times and 7 times the current level. The installed capacity is expected to reach 700 GW and 2,500 GW. That of clean energy stands at 400 GW and 1,500 GW, accounting for 57 per cent and 63 per cent of the total. African sustainable energy development calls for expedited clean energy and African energy interconnection. The general approach is to effectively develop its rich and quality clean energy resources based on its resource endowment, build large-scale hydro, wind and solar power bases and distributed generation, and lose no time in the construction of backbone grids in all countries and the five large regional grids to promote intracontinental and cross-regional interconnection. Meanwhile, the eastern, middle and western Africa-Europe cross-Mediterranean power pipelines and the southern and northern ends of the Africa-Asia cross-Red Sea interconnection projects should be carried out. With these efforts, we can realise cross-border, cross-regional and intercontinental allocation of clean energy and deliver the energy landscape with hydro, wind and solar power complementing each other to meet

the demands for continental power consumption and inter-continental power transmission. Eventually, we can bring to fruition a safe, clean, economical and efficient African Energy Interconnection.

Intracontinental cross-border and cross-regional grid interconnection

North Africa is the hub linking the Eurasia grid, accounting for 16 per cent and 41 per cent of the total population and power consumption in Africa. The five countries bordering the Mediterranean have realised transnational grid interconnection. To complete the North Africa grid, we need to accelerate cross-border interconnection projects between Sudan and Egypt, Egypt and Libya, and Libya and Tunisia to realise regional power balance. At the same time, we must advance intracontinental cross-regional power transmission projects between Sudan and Ethiopia, and Niger and Morocco to absorb hydropower coming from the East and the West. Finally, we will form an interconnected backbone grid system at 500/400 kV within the region and align a grid landscape asynchronously, interconnected with eastern and western power grids.

Central Africa accounts for 11 per cent and 3 per cent of Africa's total population and power consumption respectively, with grids in most countries yet to be connected. To build the Central African grid requires us to strengthen grid interconnection among countries along the Atlantic rim and promote the Democratic Republic of the Congo-Republic of the Congo-Gabon-Republic of Equatorial Guinea-Cameroon Grid Interconnection Project, to meet local power demand. At the same time, we need to build the Grand Inga hydropower base-South Africa power transmission project and form a Central Africa 765/300 KV backbone grid system synchronously interconnected with western, eastern and southern grids. In this way, the interconnection pattern can support south-to-north cross-regional transmission from large hydropower stations in Central Africa.

East Africa accounts for 23 per cent of Africa's total population and 4 per cent of power consumption with low-voltage cross-border interconnection and limited infrastructure. The East Africa grid involves regional interconnection projects between Ethiopia and Sudan, and Ethiopia and Kenya, and cross-regional transmission projects between Ethiopia and Egypt, Ethiopia and Mozambique, as well as Kenya and Tanzania. Consequently, we will form a 765/400 KV grid in East Africa, synchronously interconnected with the South Africa grid and asynchronously interconnected with the North Africa grid.

In West Africa, power demand and supply is self balanced. Currently, West Africa accounts for 31 per cent of the total population and 10 per cent of power consumption in Africa, with underdeveloped regional interconnections. The West Africa grid requires strengthened regional transnational grid interconnection. The Benin-Togo-Ghana and Nigeria-Niger-Burkina Faso interconnection projects need to move forward to guarantee local power demand. Nigeria-Morocco, Nigeria-Cameroon and other cross-regional power transmission projects are to be constructed for cross-regional power complementation. With these efforts, a West Africa 765 KV double-ring backbone grid system could be formed, synchronously interconnected with the Central Africa grid and asynchronously interconnected with the North Africa grid.

Southern Africa is an important consumer of hydropower from Central and East Africa, accounting for 19 per cent of the total population and 43 per cent of power consumption in Africa. Most of the countries have realised regional cross-border interconnection. Southern Africa's grid requires accelerated Tanzania-Zambia and Malawi-Mozambique regional grid interconnection projects as well as the Democratic Republic of the Congo-Angola-Namibia cross-regional power transmission project to meet the need for clean energy development in the region, and clean power imports, such as hydropower from Central Congo River and the Eastern Nile outside South Africa. In this way, a west-to-east backbone grid system composed of multiple 765 KV grids in South Africa will be structured with synchronous interconnection with the Central Africa Grid and the East Africa grid.

Inter-continental grid interconnection

An Africa-Europe-Asia grid interconnection is an important

component of global energy interconnection.

"Africa will be able to provide 3,300 TWh of clean electricity on a yearly basis, cutting 2.8 billion tons of CO_2 emission."

Europe is making headway in clean development and electricity replacement. This is creating a huge demand for clean electric power and makes Europe an important consumer of clean energy from Africa. Against this background, it is imperative to hasten the Morocco-Portugal, Tunisia-Italy, and Egypt-Cyprus-Greece cross-Mediterranean power transmission pipelines in the west, middle and east and Grand Inga-France and Grand Inga-Germany power transmission projects. On that account, a North Africa-Europe grid interconnection will be established that underpins transcontinental consumption of clean energy such as solar power from North Africa and hydropower from Central Africa.

West Asia and Africa are complementary in resource reserves, which will generate huge alternating peak load benefits. Therefore, we must speed up Egypt-Saudi Arabia and Djibouti-Yemen power transmission channels so that grids in Africa and West Asia are asynchronously interconnected and electricity from two continents can complement each other on a larger scale.

African energy interconnection can generate huge integrated economic, social and environmental benefits.

First of all, such interconnection ensures sustainable energy supply. Massive clean energy development and large-scale grid construction can bring electricity to a greater proportion of Africa's population and solve the problem of limited access to electricity. Africans can enjoy a better life with sustainable energy for all.

Secondly, interconnection promotes clean development in Africa. By 2050, Africa will be able to provide 3,300 TWh of clean electricity on a yearly basis, cutting 2.8 billion tons of CO_2 emissions. It protects our environment and contributes to sustainable development.

Thirdly, it drives economic growth. Some USD 7 trillion will be invested to build Africa's grid, which is set to be an important impetus for economic growth in the region. At the same time, the tariff of clean energy transmitted from Africa to Europe is USD 5-7 cents/kWh lower than that of locally-generated power. Africa can then make full use of its rich energy reserves to fuel its economic growth.

Fourthly, interconnection promotes regional integration in Africa, through which a huge energy market will be established. By 2050, the intracontinental and intercontinental power trade will exceed 500 TWh, further strengthening economic and trade ties among Africa, Europe and Asia. Regional economic integration will revive socio-economic development in Africa.

Jointly open a new chapter in building African energy interconnection

It is a shared aspiration of African countries to energise power infrastructure. And African energy interconnection possesses great significance to socio-economic prosperity, as it drives an innovative development of energy and power sectors at a higher level. At this

critical time for both challenges and opportunities, we need concerted efforts from all African nations.

GEIDCO is willing to align pragmatic, win-win collaborations with all sides to shape up African energy interconnection based on equality and mutual benefits. To achieve the goal, I would like to propose the following:

(1) Unite all forces for a broader consensus. We can leverage the influence of international organisations such as the African Union, United Nations Economic Commission for Africa, and International Hydropower Association, as well as governments, businesses, research institutes, universities and the media to improve public communications and refine awareness of the concept on GEI. Thereby we can find more like-minded individuals around the globe.

(2) Invigorate energy development design. Research results on GEI can be integrated with regional energy and power development plans. We can collectively probe major issues of energy endowment, power demand and supply, and grid interconnection plans in Africa. These efforts will guide and avail the development of large-scale clean energy bases and the construction of national backbone grids and cross-border and intercontinental power transmission arteries.

(3) Bring key projects into play. A series of African energy interconnection projects are ready to be implemented as soon as possible. They bear valid benefits and demonstrative effects. In addition, some power output projects for energy bases and cross-border and intercontinental power transmission projects need to be pressed ahead with as a guide and demonstration. They will push forward a general pattern of grid connectivity in Africa.

"We need to work out an inter-governmental cooperation framework and working mechanism regarding energy infrastructure connectivity."

(4) Promote policy coordination among countries. Let's not forget other important players in this course: international organisations and governments. We need to work out an inter-governmental cooperation framework and working mechanism regarding energy infrastructure connectivity, which is conducive to the introduction of pro-clean-energy and pro-grid-connectivity policies and regulations. Smooth work between countries can also lead to strengthened cross-border power trade and cooperation and create a favourable climate for African energy interconnection.

GEI and African energy connectivity can inject a new momentum into the socio-economic development in Africa. They are in the interest of all African countries. To make them a reality in the future, we need a more united community. Let's work hand in hand for African energy interconnection with more communication and common consent, and make our due contribution to the sustainable development of Africa ■

Exploring the facets of interconnectedness

Remarks by

Lucio **Monari**

Director, Energy and Extractives Global Practice,
The World Bank Group

// The World Bank Group's commitment to supporting sustainable hydropower is rooted in our mission, which is to eliminate poverty and promote shared prosperity, and to do so in a sustainable manner.

Since the World Bank is often asked where we stand on hydropower, I want to confirm here that the World Bank Group fully supports the development of sustainable hydropower. We do not believe that either small or big projects are necessarily beautiful, and we do not believe that hydropower is no longer needed because of the rapid – and very welcome – growth of solar and other renewables. We do believe in working in partnership with our clients to help them develop the solutions they need. Following this approach, we currently have some USD 6 billion invested in hydropower programmes, including greenfield and rehabilitation projects, as well as policy and capacity-building activities.

This money is leveraging a further USD 19 billion in public and private finance for individual projects.

More specifically, we believe that sustainable hydropower can offer three key benefits:

First, it provides energy, which is vital for lifting people out of poverty, as articulated by the Sustainable Development Goal on sustainable energy for all;

Second, hydropower can provide clean and low-emission energy at scale, which is vital to achieving the climate targets agreed in the Paris Agreement on Climate Change;

Third, hydropower dams can help provide a number of other water-related services, including water supply, irrigation and flood control.

The theme of this congress is 'Better hydro in an interconnected world'. So as we think about better hydropower from

a World Bank Group perspective, there are three types of interconnectedness that I would like to highlight: sectoral, regional, and technical.

Hydropower involves capturing energy from water, and as we all know, this can be done from the smallest scale right up to the largest power plants on earth. When hydropower involves dams that regulate flow or store water, these dams can also contribute to irrigation, water supply, flood control, and navigation. Dams are, both literally and figuratively, a concrete manifestation of the food-water-energy nexus, and hydropower can make a unique contribution to developing economically-critical dams in a financially sustainable way. The other side of sectoral interconnectedness is the large environmental and social impacts sometimes associated with dams. It is therefore critical that when we plan for and develop hydropower we keep this sectoral interconnectedness in mind – both to get the maximum benefits from projects, as well as to minimise and mitigate downsides.

The second kind of interconnectedness we need to focus on stems from cross-border energy trade as well as transboundary river basins. Energy trade provides great benefits from both a cost and energy mix perspective, and is particularly useful where the domestic markets for energy are small. Where hydropower is based on transboundary rivers, there is also the opportunity to develop projects regionally. For example, Burundi, Rwanda and Tanzania are jointly developing the Rusumo Falls project with World Bank support.

The third kind of interconnectedness I want to briefly mention is the particular value of hydropower in providing energy storage, rapid deployment, frequency control, black-start capabilities, and other ancillary services. As climate imperatives, technology and financing come together to enable the rapid scale up of solar and wind power, the value of hydropower in the grid increases. Hydropower's ability to store and rapidly deploy makes it an ideal partner to more variable renewables. The World Bank Group firmly believes that hydropower, solar and wind are usually complements rather than substitutes.

In addition to these three forms of interconnectedness, there is a final one that I would like to turn to, which is the interconnectedness among all of us in the global hydropower community. Whether we are governments, developers, civil society, financiers or consultants, we share a common interest in the sustainable development of hydropower. During the technical workshops that took place ahead of the congress, we worked with a number of participants on dam safety, climate resilience, sedimentation, and improving operation and maintenance approaches. In the congress, we will be contributing to sessions on measuring reservoir greenhouse gases, basin planning, and financing. We are also, in partnership with IHA, launching a compendium of case studies on 'Better hydro' which draws from our collective experiences in implementing the Hydropower Sustainability Assessment Protocol.

We live in an interconnected world and the World Bank Group believes that hydropower can make large contributions across sectors, countries and grids. We hope to keep working with all of you to help develop hydropower sustainably ■

Developing sustainable hydropower in Africa

Speech by

Wang Lin

President, China Three Gorges Corporation

// The congress presents an occasion to contribute to Africa's clean energy cause and advance the global initiative for clean energy development.

Since I first set foot in Africa, I have been impressed by the continent's hospitality, long history, and rich culture. This is a land of wonders, home to the world's largest desert - the Sahara, which occupies one third of the continent's area - and the world's longest river - the Nile, which is a cradle of ancient civilisation, as well as the birthplace of the earliest water conservancy project.

However, clean energy development in Africa is facing both opportunities and challenges. As estimated by the International Energy Agency, Africa's theoretical hydropower potential is 283 GW. According to statistics from the International Hydropower Association, its total installed hydropower capacity stands at just 30 GW, a mere 10.6 per cent of its full potential. By 2016, there were still about 645 million Africans without access to electricity. African countries face common challenges in hydropower development, including colossal initial investments, sluggish planning and construction for long-distance cross-border transmission lines, environmental and social issues, and technological gaps. This World Hydropower Congress has gathered a number of clean energy experts from around the globe. This gives us a wonderful chance to discuss how we can seize opportunities and take on challenges in developing hydropower for Africa.

"By 2020, five of the world's top 10 hydropower stations by installed capacity will be managed and operated by CTG."

CTG was founded to build the Three Gorges Project and to develop the hydropower resources of the Yangtze River. It has gained a reputation for the success of the Three Gorges project and grown stronger with large-scale

hydropower development on the upper Yangtze River. As the owner and operator of six large-scale hydropower projects on the main stream of the Yangtze River, we are devoted to developing clean energy, having accumulated a trove of technical know-how and financial resources. We are now China's biggest clean energy corporation and the world's biggest hydropower developer. If you combine our consolidated installed capacity, installed capacity under construction, and minority equity-based capacity, the total exceeds 118 GW, the equivalent of five Three Gorges projects. Most of that amount comes from clean energy sources, like hydropower, wind, and solar. It is predicted that, by 2020, five of the world's top 10 hydropower stations by installed capacity will be managed and operated by CTG.

The clean energy projects we have put into operation are playing crucial roles in increasing the supply of clean energy and combatting climate change. Take the Three Gorges project. By 1 March 2017, the project had generated more than 1 trillion kWh, which translated into saving 319 million tons of standard coal and cutting carbon dioxide emissions by over 800 million tons.

We have taken an active part in clean energy projects as a developer and investor.

"CTG is now the second largest private firm in Brazil's electric power industry."

Guided by green development, CTG has given full play to its own advantages as we have engaged in clean energy development and investment worldwide. Our overseas total installed capacity, including consolidated, under construction, and minority equity-based, has reached 15 GW. In 2012, we became the largest shareholder in Energias De Portugal. In 2015, the International Finance Corporation and the Silk Road Fund bought stakes in China Three Gorges South Asia Investment Limited in a move to pool efforts for hydropower development in Pakistan and South Asia. In 2015 and 2016, we ramped up investments in clean energy projects in Brazil. We are now the second largest private firm in the country's electric power industry.

We have been involved in the construction of high-quality electricity sources in Africa to promote the development of the continent's energy interconnection.

Cooperation between China and Africa on hydropower dates back a long time. In May 1966, the KinKon hydropower station, built by China International Water & Electric Company, a subsidiary of CTG, was completed. This was the first hydropower project built in Africa with Chinese aid. The Merowe hydropower station, known as Sudan's Three Gorges project, provides four million people along the Nile with water for everyday life and production. In Guinea, CTG braved the height of the Ebola crisis to avoid disruption in the construction of the Kaleta hydropower station. The project was put into operation on schedule and has since supplied clean electricity to the country's capital Conakry. Together with the Souapiti hydropower plant, this project laid the groundwork for the development of power transmission and distribution between the member states of the Gambian River Basin Organisation

(OMVG). As power transmission and distribution infrastructure in West Africa has improved, these two power stations have become key electricity sources playing important roles in the region's supply of clean electricity.

As is widely known, the Inga hydropower project in DRC can meet 70 per cent of Africa's demand for electricity. Since 2011, CTG has tracked the progress of the Inga project and led a joint venture on the Chinese side. Years of in-depth research has positioned us where we can jump in anytime and make a real difference for this project that will light up Africa.

Our suggestions for Africa's clean energy development

(1) Do more to tap into Africa's hydropower resources: hydropower is Africa's most notable energy advantage. Rivers like the Congo and the Zambezi meet every condition for developing hydro projects. I suggest studies be stepped up to figure out how to move faster to make such projects materialise, which will make more efficient use of Africa's hydropower and entrench electricity security on the continent.

(2) Enhance efforts to plan and build power grids in African countries: to develop clean energy, Africa can draw on the world's mature technologies for smart grids and ultra-high voltage long-distance transmission to improve grid planning and construction within countries and between different parts of the continent. This is how Africa can achieve electricity interconnectivity and meet the demand for electricity despite the uneven distribution of hydropower.

(3) Reinforce intra-Africa cooperation on hydropower: I suggest continuous efforts be made to strengthen intra-Africa cooperation on hydropower development. African countries can work together, for example, to develop hydropower on rivers that they share and to build transmission or distribution lines that cross borders. Such projects can strike an energy supply balance and benefit them all.

(4) Remain committed to green development for harmony between man and nature.

By no means should hydropower development progress at the expense of Africa's ecosystem and long-term interests. Prominence should be given to environmental protection and resettlement. Experience should be drawn from the rest of the world regarding how to protect the environment and people during hydropower development. Guidelines provided by international organisations should be followed so that their strengths can be leveraged.

CTG is willing to work with every stakeholder to drive sustainable development for Africa's clean energy, whereby we can improve people's lives. We look forward to cooperation on technology and investment. We propose setting up a community of shared future, where all parties join hands to develop high-quality power projects that underpin the Global Energy Interconnection. This is also a process of carrying on international friendships, benefit delivery and win-win results. Let's unite as one to pursue mutual benefits and achieve 'Sustainable Energy for All' ■

Sustainable energy for all in practice

Speech by

Rachel **Kyte**

CEO, Sustainable Energy for All

// In 2015, the world's leaders agreed to a set of universal Sustainable Development Goals. One of those goals calls for us to secure affordable, reliable, sustainable and modern energy for all by 2030.

A few months later, 195 nations signed the Paris climate agreement – committing to putting the world on a 'well below 2°C' trajectory. We made these promises to each other.

Almost two years later, more than 1 billion people still have little or no access to electricity. Over 3 billion people do not have access to clean cooking. Women, children and low income people are disproportionality affected by energy poverty and the impacts of climate change. CO_2 concentrations and temperatures continue to rise.

The pressure for action becomes more urgent every day. The combined vision of the Sustainable Development Goals and the Paris Agreement means that we need an energy transition to cleaner, reliable, affordable energy systems that provide electricity to all.

The energy transition means that energy pathways plotted by communities, cities and countries and regions need to put energy efficiency first and ensure that energy plans put energy access at their heart. Inceasingly, that means that energy plans need an integrated approach that embraces centralised and decentralised sources and a much greater share of renewables in the mix – for which in many parts of the world further developing regional energy pools and interconnection will be essential.

We also need a new generation of institutions to manage our energy systems. It is impossible to imagine energy systems which meet the goals we have set for them, without managing and developing them in conjunction with critical decisions around water resources and food systems.

At Sustainable Energy for All we focus on supporting leaders to make decisions that will allow them to manage the transition as quickly, smoothly, and cheaply as possible. The price of inaction is higher than action in most cases.

In April 2017, at the Sustainable Energy Forum in New York City, we launched the 2017 Global Tracking Framework report. This framework – a product of the SEforALL Knowledge Hub, co-led by the International Energy Agency and World Bank – is the global dashboard for progress on SDG7.

"While it's possible to secure sustainable energy for all by 2030, we are not on track."

So where are we? As you might guess, the top line of the Global Tracking Framework report is that, while it's possible to secure sustainable energy for all by 2030, we are not on track. According to the Energy Transitions Commission, the incremental cost of decarbonising the energy systems over global investment trends under business as usual is not prohibitive. So, what does that mean for the leaders gathered here, today, at the World Hydropower Congress? I want to challenge you.

First, hydropower is already a significant part of the renewables mix in many countries. In 2015 it represented two-thirds of the renewable power capacity installed globally. Within Africa, installed hydropower capacity represents 80 per cent of renewable capacity and generates over 90 per cent of renewable electricity.

What's more, investment in hydropower remains attractive alongside solar and wind energy. In 2015, investment in large hydroelectric dams reached $43 billion, equivalent to 40 per cent of global wind investments (of USD 110 billion) and 27 per cent of global solar investments (of USD 160 billion).

Clearly hydropower offers attractive properties for any energy system – ticking boxes on affordability, reliability, resilience, as well as being cleaner.

But when we look at the project pipeline, it is stale. Too many projects languish at many of the early pre-planning and planning stages. While those governments that have moved important projects through in the past few years, and those financiers that have found ways to be part of funding structures that work in today's power markets should be congratulated, the current pipeline does not look like one off which we can achieve speed and scale.

I hope that from project preparation, to coordinated action on standards, to new approaches to master planning and innovations in risk sharing, we can collectively nudge this sector forward.

Second, to Africa. Africa is home to 600 million people without access to electricity. Imagine the economic activity that can develop if the productive demand of that segment of the population is met.

Hydropower is the most economical solution for large-scale renewable electricity generation in Africa. Large-hydropower is less expensive than most technologies of any type for power production – costs in Africa can be as low as USD 0.03/kWh. The average is approximately USD 0.10/kWh.

Less than 10 per cent of the economic potential of hydropower is currently exploited. Can that number increase while protecting the environmental assets of the region and without undermining the social fabric of

communities affected?

"I hope that from project preparation, to coordinated action on standards, to new approaches to master planning and innovations in risk sharing, we can collectively nudge this sector forward."

While the development community focuses too much of its time on large complex potential hydro systems, can we come together, using new data and evidence and techniques on how to plan systems effectively, pool resources together to be able to roll out projects that can harness the significant unexploited small hydropower potential, an important source of electricity for rural populations.

There is essential work to be done on investment climate reform, delivery unit development to drive through energy plans from paper to electrons flowing, more early stage dialogue with the private sector on a consistent basis and much more engagement of communities. Those who invest in these capacities and processes are rewarded with strong investment interest and project development.

"Let's stop creating policy for projects and develop policy for markets."

And third, policy matters – it is an accelerant in the energy transition, in the hydro sector as well as others. Here is a policy to-do list:

- Issues of sustainability and climate variability need to be addressed systematically across all jurisdictions. This is smart in terms of ultimate productivity of projects, but because investors increasingly will require it. Assets that will operate in the volatility of the next few decades need to be resilient and effective.
- Regional policy-making and coordination is urgent. Let's stop creating policy for projects and develop policy for markets – national and regional.
- Create a level playing field for centralised and decentralised energy generation – integrations will allow electrification rates to increase faster and more affordably.
- Drive forward the policy underpinning of a healthy pipleline – dam safety, silt removal and management, environmental and social impact management.

Hydropower offers enormous potential as a reliable and cost-effective source of power. As a solution to storage and water resource management, within integrated energy planning. It needs to continue to make its case and to continue to evolve best practice and communicate that are based on good evidence.

The one thing that everyone agrees on – enthusiasts and critics alike – is that we have little time. Perhaps the pressure of time can force us to a degree of collaboration that has sometimes eluded us up to now.

There is a bright future. Technology and practice has advanced. There is no shortage of capital in the world – attracting it to hydro assets in a world of uncertainty will require a concerted effort, on the back of good, stable policy frameworks. It is a time for leaders, across industry and across governments. It is the one ingredient we cannot substitute ■

Creating inclusive growth with hydropower

Speech by

Abdalla **Hamdok**

Ag. Executive Secretary, United Nations Economic Commission for Africa

// Advancing hydropower globally, and in particular in Africa is a very timely and relevant issue.

Indeed, Africa has untapped hydropower potential and the quest for 'better hydro', as advocated by the International Hydropower Association, is at the heart of the current discourse to accelerate increased energy access and spur industrial development across the continent.

The calibre of attendees in the congress speaks volumes to our collective resolve to ensure that global and regional strategies for developing hydropower potential are effectively articulated and negotiated.

Hydropower is well-known as one of the most important power sources and produces more than three quarters of the world's renewable energy output each year. The carbon emissions throughout its lifecycle – from construction to operation and decommissioning – are the lowest of all other renewable sources, including wind and solar.

Against this backdrop, a number of countries are almost exclusively using hydropower for their baseload electricity. At the same time, hydropower across Africa has become the renewable energy of choice and accounts for around 80 per cent of all non-fossil fuel use.

More than 600 million people in Africa do not have access to electricity and most households rely on traditional biomass for cooking, of which the consequences are known. Reportedly, this situation has hardly changed since 1990. Consequently, addressing the energy infrastructure gap is considered as one of the priorities of many African governments, development partners and other relevant African institutions.

However, it is equally important to guard against negative impacts of hydropower development and to pay close attention to climate resilience and social inclusion. This is mostly linked to growing concerns regarding hydropower sustainability,

including the overreliance on hydropower, which could possibly compromise energy security in many countries, especially in the context of drought.

Furthermore, I was glad to note that the agenda of the congress includes items on environmental and social impact in the context of hydropower development and deployment. Among many other issues in this area, it is important to develop an integrated approach to the management of water for irrigation and energy production.

In the context of furthering the implementation of both the global Sustainable Development Goals and the African Union Agenda 2063, the Economic Commission for Africa, together with the African Union, and in very close partnership with key stakeholders, is working on a number of programmes and initiatives to promote low-carbon energy development as well as innovative financing regimes for clean energy infrastructure projects.

Africa is confronted today with emerging developments which present major challenges and opportunities. While advancing 'better hydro', we need to give special attention certain policies that can help foster transformative and inclusive development.

First, leveraging our growing urban population for future economic diversification. Africa's urban population is projected to reach about 50 per cent by 2035 with increasing demands for employment, services and infrastructure, including energy.

Second, adopting 'greening industrialisation' as an alternative economic pathway to industrialisation. As a latecomer to industrialisation, this presents the opportunity for Africa to achieve the type of structural transformation that yields sustainable and inclusive growth, creating jobs while safeguarding the productivity of natural resource assets.

Third, harmonising the rules and regulations for regional electricity markets. The low level of intra-African trade and limited integration of continental markets have reinforced a pattern of trade that is dominated by the export of basic commodities. Hydropower development, and particularly the cross border interconnections will increase energy markers as well as boost intra-African trade in electricity, and other commodities.

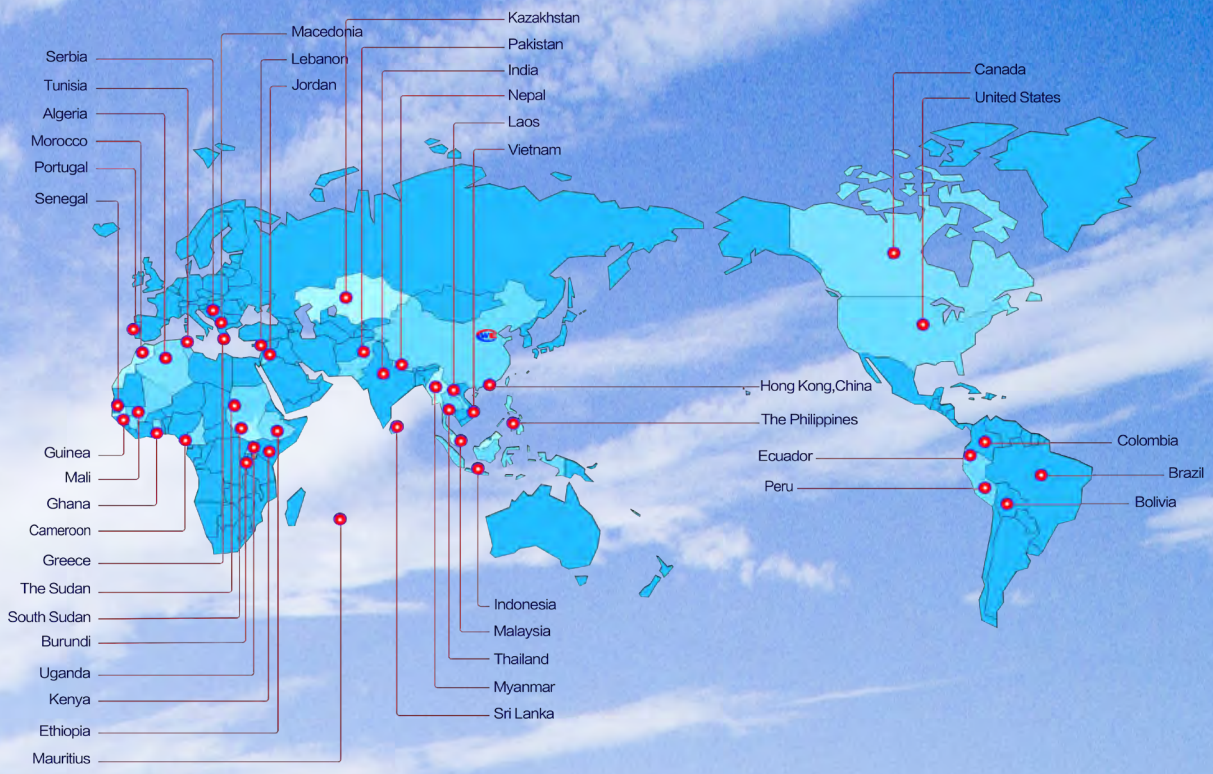
Yes, Africa is endowed with vast renewable energy resources. However, its true wealth lies with the millions of Africans spread out across the continent and determined to drive change. With clear vision coupled with strong and coherent policy action to promote faster and more inclusive growth, the continent has the potential to take the lead in innovation, technologies and business models that utilise hydropower optimally and efficiently.

Ensuring universal access to affordable, reliable and modern energy services will only be possible in a better-connected world, one where synergies and partnerships are sought among a large number of stakeholders.

ECA looks forward to new partnerships that will be crafted to better manage hydro resources in Africa and the rest of the world.

I wish you successful deliberations and thank you for your kind attention ■

International Business Footprints Of CTG



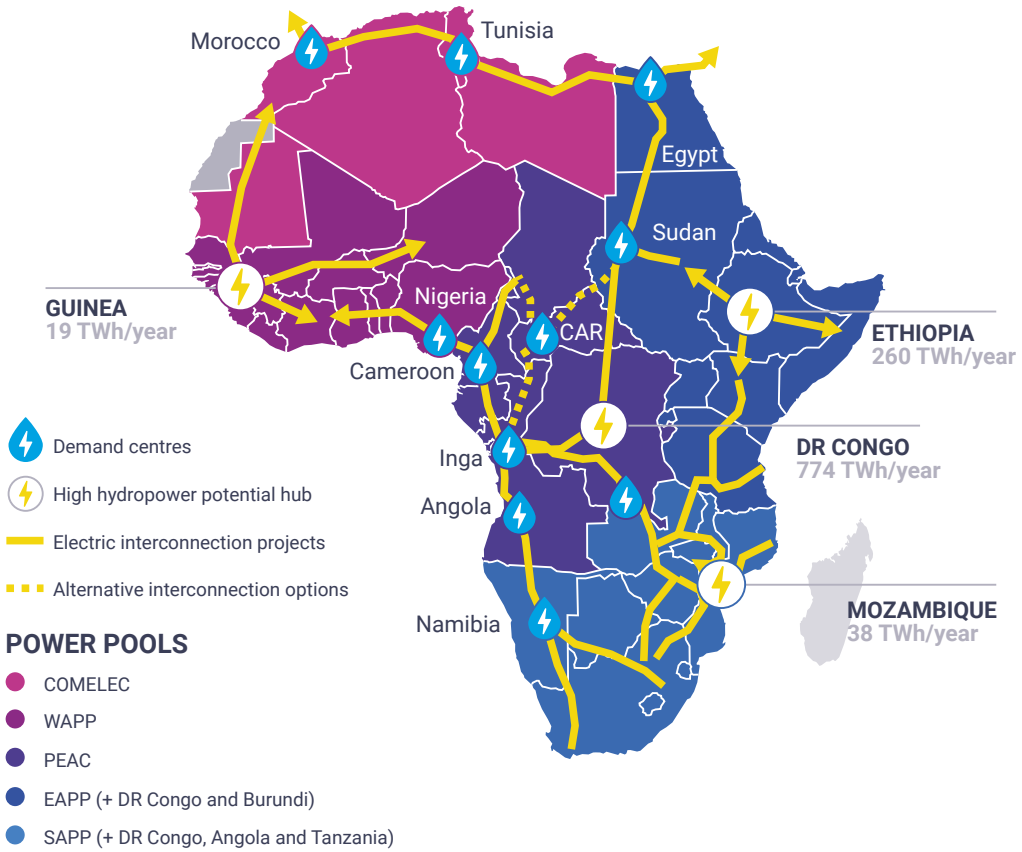
For hydro, we excel in:

1. Large hydropower project construction management
2. Large hydro turbine units installation and commissioning
3. Large hydropower project operation management
4. Joint dispatch of cascade power plants
5. River basin environmental protection and rehabilitation
6. Large project financing and capital operation
7. Large-scale resettlement and relocation
8. Industrial chain integration and innovation

FOCUS

Hydropower and interconnections in Africa

Africa still faces enormous challenges in its energy sector, including low generation capacity and efficiency, high costs, unstable and unreliable energy supplies, poor access to modern energy, and insufficient energy infrastructure. The African Union Commission writes about multiple collaborative initiatives that are mobilising action to address these challenges.



In Africa, more than 600 million people have no access to modern energy services. Only about 31 per cent of the population has access to electricity in sub-Saharan Africa, with about a 19 per cent electrification rate in rural areas. This is one of the biggest challenges in development because it is evident that, without access to clean and affordable energy services, economic development and absolute reduction of poverty is virtually impossible. The majority of rural communities continue to use traditional biomass fuels and kerosene, causing indoor air pollution that results in millions of deaths every year – mostly women and children.

The huge reserves of energy resources on the continent – both renewable and non-renewable – provide Africa with great opportunities to improve modern energy access, which will accelerate industrialisation, reduce poverty and sustain the impressive economic growth experienced in the last decade.

The current African energy mix is not sustainable and, continuing along the current path, the energy system will not be compatible with meeting the energy Sustainable Development Goals, and thus with realising a sustainable energy future.

Indeed, realising a sustainable energy future will require a well-balanced and diversified energy mix, with a greater contribution of renewable energy resources and cleaner energy sources, as well as higher efficiencies in the energy chain.

Over the next three or four decades, fossil fuels will continue to dominate the African energy mix. It is essential to encourage their efficient use, and to develop and accelerate cleaner fossil-fuel technologies to reduce the impact of human-induced emissions on quality of life and the natural environment.

Given its great potential (see the map, above), hydropower is expected to play a significant role in developing the future energy sector in Africa in both urban and rural areas. Hydropower is seen as a good option to increase the contribution of renewable energy in the African energy mix, provided projects are formulated in a bankable form, and the social and environmental implications are suitably addressed.

Africa accounts for about 12 per cent of the world's technically feasible hydropower potential, and the continent has the potential to generate over 1,800 TWh per year of electricity

from this resource. Although the current utilisation of hydropower in Africa is less than 8 per cent of what is technically feasible, the potential presents huge opportunities to utilise hydropower at the regional, national and local levels.

In the semi-urban areas, rural areas, and areas isolated from the grid, micro and mini hydropower systems can play major roles in providing and expanding access to affordable, reliable and modern energy services to the population, and in particular for low-income segments.

The development of multipurpose dams provides a viable and cost-effective means for Africa to boost electricity generation and also provide water for irrigation and sanitation, as well as contributing to reduced flood risks.

We need to recognise that climate change has the potential to affect hydropower generation, given frequent fluctuations in rainfall and increased droughts and flooding in many parts of this continent and the world. There is therefore a need for all our countries and institutions to seek a better understanding of climate change impacts, and to build climate change adaption and mitigation plans into our hydropower sector development plans.

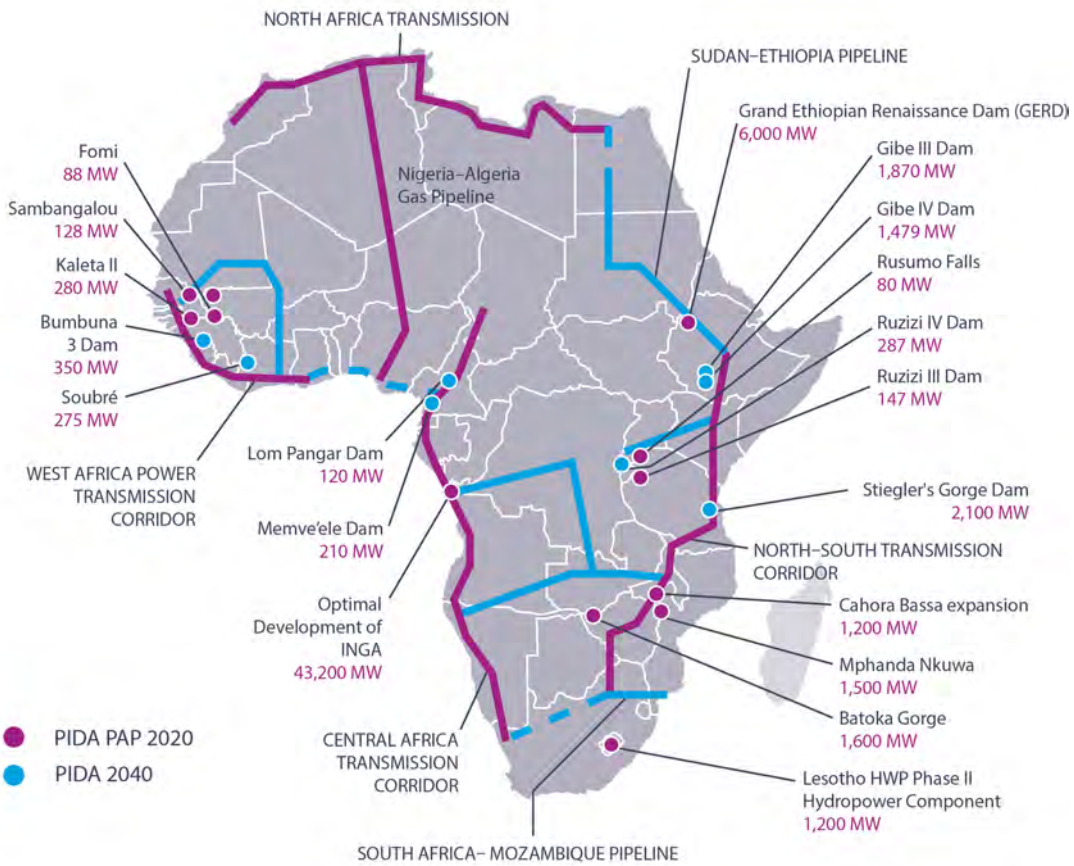
In order to meet the growing energy demand, promote power trade between countries and regions, and improve energy security, the African Union has launched various energy initiatives and partnerships for development of the continent's vast quantities of renewable energy resources that are today untapped, such as hydropower, solar, wind, geothermal and bioenergy, as well as the promotion of electricity trade between countries and regions.

The following initiatives, among others, are focusing mainly at pushing ahead with renewable energy development on the African continent:

- The Program for Infrastructure Development in Africa (PIDA) is dedicated to facilitating continental integration, socioeconomic development and trade, through improved regional infrastructure; the energy priority projects include nine hydropower projects to be implemented by 2020 and 20 hydropower projects by 2040, totaling over 54 GW, as well as four power transmission corridors (see map, right). The successful implementation of PIDA will, among other work, enable African countries to reduce energy costs and increase access to nearly 70 per cent, by providing access to an additional 800 million people by 2040, as well as ensuring water and food security.
- The Hydropower 2020 Initiative is aimed at designing and implementing strategies focused on stimulating and accelerating the development of the 300 GW hydropower potential in the major river basins on the African continent.
- The East African Regional Geothermal Programme includes the Geothermal Risk Mitigation Facility, which aims to encourage public and private investors by providing grants for investment in the development of geothermal energy for power generation, which has a potential of over 15 GW in East Africa rift system countries.
- The assessment of solar energy potential in the Sahara and Sahel regions has shown the potential of achieving full electrification in all North African and West African countries by 2030 through the dissemination of Concentrating Solar Power (CSP) and other renewable energy technologies.
- The implementation of the Renewable Energy Cooperation Programme (RECP) under the Africa-EU Energy Partnership aims to bring access to modern and sustainable energy services to at least 100 million Africans by 2020, and implement various renewable energy systems in Africa, including 10,000 MW of new hydropower.
- In Africa, the Sustainable Energy for All (SE4All) initiative has the main objectives of ensuring universal modern energy access as well as doubling the use of renewable energy and energy efficiency by 2030.
- The Africa Renewable Energy Initiative (AREI) seeks to achieve at least 10 GW of capacity by 2020 and, as an aspiration, increase renewable energy generation from 100 to 300 GW by 2030.
- The US Power Africa Initiative aims to add over 10 GW of clean and efficient electricity generation capacity.
- The African Development Bank New Deal for Energy in Africa aims to achieve Universal Energy Access by 2025.
- The International Renewable Energy Agency (IRENA)'s Clean Energy Corridor Programme intends to accelerate the production of electricity from renewable energy sources in Africa.
- The AU programme, in collaboration with the European Union, on 'continental harmonised regulatory framework for the energy sector in Africa' aims to enable energy market and infrastructure development.

Energy markets will stimulate energy diversification, and therefore will help to enhance energy security through provision of energy alternatives. This will ensure energy security for Africa through efficient and sustainable energy integration on the continent. In addition, energy markets will lead to lower energy prices through competition and market mechanisms, enhance access to modern energy sources and open the locked borders for intra-African trade.

The continuing and gradual successes of these initiatives reassures us that regional and cross-border infrastructure will be a major component of the future African energy system.


NORTH AFRICA TRANSMISSION
SUDAN–ETHIOPIA PIPELINE
Grand Ethiopian Renaissance Dam (GERD)
6,000 MW
Gibe III Dam
1,870 MW
Gibe IV Dam
1,479 MW
Rusumo Falls
80 MW
Ruzizi IV Dam
287 MW
Ruzizi III Dam
147 MW
Fomi
88 MW
Sambangalou
128 MW
Kaleta II
280 MW
Bumbuna
3 Dam
350 MW
Soubré
275 MW
Nigeria–Algeria
Gas Pipeline
WEST AFRICA POWER
TRANSMISSION
CORRIDOR
Lom Pangar Dam
120 MW
Memve'ele Dam
210 MW
Optimal
Development of
INGA
43,200 MW
Stiegler's Gorge Dam
2,100 MW
NORTH–SOUTH TRANSMISSION
CORRIDOR
Cahora Bassa expansion
1,200 MW
Mphanda Nkuwa
1,500 MW
Batoka Gorge
1,600 MW
Lesotho HWP Phase II
Hydropower Component
1,200 MW
CENTRAL AFRICA
TRANSMISSION
CORRIDOR
SOUTH AFRICA– MOZAMBIQUE PIPELINE
PIDA PAP 2020
PIDA 2040

This calls for harmonised strategies and frameworks, at the policy, regulatory and institutional levels, among countries and regions, that will enhance greater coordination and cooperation, aimed at enabling energy markets and infrastructure development.

In close cooperation and permanent dialogue with all partners, the African Union Commission (AUC) is committed to strengthening the coordination and harmonisation of all of these initiatives.

The African Union Agenda 2063 highlights the need to enhance regional and continental efforts for accelerated and integrated infrastructure development, and the effective and sustainable deployment of energy resources on the continent. AUC has already started implementing some flagship projects of Agenda 2063 in the infrastructure sectors as drivers for development and integration, such as the Grand Inga hydropower project.

AUC is contributing to mobilising all development partners and private sector participants to support the Grand Inga project, which has a continental impact, as well as the development of power transmission corridors to enhance power trade and better energy security at regional and continental levels.

The first phase of this project, named Inga 3, is among the nine hydropower projects selected as PIDA priorities to be implemented by 2020. It is expected to be launched very soon, as well as other hydropower projects such as Ruzizi 3, Rusumo Falls, Mphanda Nkuwa, Sambangalou and Batoka Gorge, in order to generate the electricity needed to contribute to meeting the forecasted power demand and increase access to electricity.

Most of these projects have reached financial closure, and the groundbreaking ceremony of the Rusumo Falls hydropower project was held on 30 March 2017.

Furthermore, the construction of the Kaleta hydropower project in Guinea was completed and inaugurated in September 2016, and the Grand Ethiopian Renaissance dam construction has made good progress, at more than 56 per cent completion.

Similar efforts are focusing on the construction of four major transmission lines to connect the continent's power pools and enable a large increase in interregional energy trade and cooperation. These projects are:

- The North-South Power Transmission Corridor, linking Egypt to South Africa. A major part linking Ethiopia to Kenya is under construction and expected to be completed by December 2018, along with some sections of the Zambia-Tanzania-Kenya interconnection linking the Eastern Africa and Southern Africa Power Pools, but this project still faces a funding gap of USD 1 billion.
- The West Africa Transmission Corridor. Linking through Côte d'Ivoire-Liberia-Sierra Leone-Guinea, this project is well advanced. and commissioning is expected in 2019. The Nigeria-Niger-Togo-Benin-Burkina interconnection project construction is expected to be launched in mid-2018 given the progress made towards financial closure.
- The Central Africa Transmission Corridor and the North Africa Transmission Corridor. These projects are still in preparation and are facing financing gaps of about USD 10.5 billion and USD 1.2 billion respectively.

AUC is encouraging member states to mobilise their own public and private domestic resources and attract foreign private investment. In this regard, countries need to ensure a competitive market based on clear legislation with enforcement of commercial law and transparency in procurement. Investors also seek effective banking systems, the presence of local skills, and good public-private partnership management skills among their public sector counterparts.

AUC is calling on development partners and the private sector to increase their focus and contribution to the above-mentioned priority investment opportunities, and join hands with African countries and regional and continental institutions involved in these programmes.

This topic was discussed at:

Hydropower and interconnections in Africa

FOCUS

Hydropower for sustainable development

With vast potential for hydropower development on the African continent, the United Nations Economic Commission for Africa (ECA) describes the growth in hydropower projects, the need to address arguments against hydropower, and how it is supporting the development of climate-resilient infrastructure.

Africa faces steep energy deficits that impede its development

Energy poverty is rife in Africa. Of the more than one billion people living in its 54 countries, over half lack access to electricity. More than 60 per cent of African households rely on traditional biomass for cooking. The Global Tracking Framework Report (Economic Commission for Africa 2017) demonstrates that this situation has hardly changed since 1990. Sub-Saharan Africa has the lowest power consumption per capita – at 317 kWh per year (225 kWh excluding South Africa). The electrification rate for rural settlements is just 19 per cent.

According to the International Energy Agency (IEA), on-grid power generation capacity was 90,000 MW in 2012. The continent's electricity supply is dominated by coal (45 per cent) from coal-generated electricity in South Africa, with a capacity of 45,000 MW. This is followed by hydropower (22 per cent), oil (17 per cent) and gas (14 per cent, mainly from Nigeria).

There has been noted insufficient and unreliable supply, and many countries in the region have resorted to costly oil generators to meet their baseload electricity requirements. Other than hydropower, electricity supply from renewables such as solar and wind is in its infancy, and used as peaking power rather than baseload. A few countries, notably South African and North African, have made significant breakthroughs in large-scale deployment of solar and wind technologies.

Africa has the lowest electricity consumption in the world because, in addition to a generation deficit, the continent has poor grid coverage. Predictably, energy consumption is dominated by 'traditional' biomass in the form of fuelwood and charcoal, particularly in rural and semi-rural areas. Modern renewable energy consumption is at less than 3 per cent.

Addressing the energy infrastructure gap is one of the priorities of the Programme for Infrastructure and Development in Africa (PIDA). The programme envisages investments of USD 360 billion in infrastructure up to 2040. Energy infrastructure will account for much of this investment, followed by transport and trans-boundary water supply.

Can hydropower reduce the energy deficit in Africa?

Generally, hydropower provides clean and affordable energy. Across Africa, hydropower has become the renewable energy of choice, and accounts for around 80 per cent of all non-fossil fuel use. A number of countries are almost exclusively using hydropower for their baseload electricity. Mozambique, Namibia and Zambia get more than 90 per cent of their power from hydroelectric sources, while Zimbabwe gets about 75 per cent from hydropower.

Africa's hydropower potential is estimated to be more than 300,000 MW. This is much the same as in Europe, but Africa has only tapped into around 10 per cent of this potential. However, 2016 saw an increase in new projects coming online in Africa, and there are many projects currently under way, which will substantially increase installed hydropower capacity.

The recent African Union Specialised Technical Committee (STC) on Transport, Transcontinental and Interregional Infrastructure, Energy and Tourism, held in Lomé, Togo (13-17 March 2017) reaffirmed, in its declaration, the important role of hydropower as a source of renewable energy in Africa.

While acknowledging the role of other energy sources, it was affirmed that hydropower is the only renewable energy source that has the potential to expand access to electricity to large populations.

The STC recommended that the African Union Commission (AUC) and the African Development Bank 'support (African) member states in the development of hydropower infrastructures'. In its energy action plans for 2017-19, the committee directed the AUC to assist the Democratic Republic of Congo in facilitating the implementation of the Inga 3 project as one of the flagship initiatives.

There now exist flagbearers of large-scale hydropower projects across the African landscape:

East Africa

- In addition to supplying growing domestic demand, Ethiopia's dams will provide regional electricity through several electricity interconnectors, including a 2,000 MW Ethiopia-Kenya linkage and a 1,600 MW Ethiopia-South Sudan interconnector.
- Uganda has signed agreements to export 50 MW to Rwanda and 30 MW to Kenya, and will import 400 MW from Ethiopia by 2018. The power will be brought in from Ethiopia through a new transmission line linking Ethiopia and Rwanda via Kenya and Uganda.
- All 10 members of the Eastern African Power Pool are due to begin electricity trading in 2017 upon completion of six cross-border transmission lines.

West Africa

- Construction ended in 2015 on the 240 MW Kaleta plant in Guinea, tripling hydropower generation.
- The USD 2 billion Souapiti project is under construction, and when completed it could add up to 500 MW of capacity and transform Guinea into a net exporter.
- The African Development Bank recently allocated USD 100 million for the rehabilitation of Nigeria's 750 MW Kainji and 758 MW Jebba hydroelectric plants on the Niger River, under the New Deal initiative.
- In 2016, the Nigerian ministry of power, works and housing pledged to expedite construction of the 3,050 MW Mambilla, 700 MW Zungeru, 250 MW Gurara and 35 MW Dadin Kowa hydropower projects, promising completion by 2023.

Southern Africa

- In 2016, South Africa inaugurated the first unit of the USD 3.5 billion 1,332 MW Ingula pumped storage hydropower plant in the Little Drakensberg mountains – Africa's largest pumped storage facility.
- New hydropower projects include Mozambique's 1,500 MW Mphanda Nkuma hydropower plant, Angola's 700 MW Cambambe hydropower plant, and Zimbabwe and Zambia's 2,400 MW Batoka George hydropower plants.

While there is a rise in large hydropower projects, there is also a long list of medium and small hydropower developments in the region. However, the challenge, which is being addressed at different levels, is that the gestation periods of these projects is often longer than planned, resulting in unavoidable budget overruns. There are also some emerging questions about climate change effects, such as recurring drought across Africa, which gives rise to water-energy nexus impacts, as well as the resilience of existing hydropower infrastructure.

However, arguments against hydropower development need to be addressed

It is a fact that hydropower produces more than three quarters of the world's renewable energy output each year. It is also stated in literature that hydropower's carbon emissions throughout its lifecycle (construction, operation and decommissioning) are the lowest of all renewable sources, including wind and solar. Be that as it may, there are also growing concerns about its sustainability, especially if it is not properly planned and carefully designed, in order to address the emerging challenges.

Also, the over-reliance on hydropower could compromise energy security, especially in the context of drought, as evidenced in Zambia and Mozambique recently. Therefore, diversification of energy supply (or integrated energy resource planning) should be pursued to mitigate this challenge. Lastly, there is a danger that that power from hydroelectric projects will benefit urban settings and industries more than rural households, where energy poverty is better addressed through more distributed energy sources.

There are also environmental and social considerations that need to be assessed and appraised. These include some localised air and water pollution, loss in biodiversity, change of landscape, relocation of settlements, and loss of livelihood and cultural identity in the direct project-affected areas.

There are also some financial pressures, as the development of hydropower projects is capital and labour intensive. The source of finance for most hydropower schemes is the public purse, and there is less private sector funding. Governments are faced with rising demands related to other competing and more important issues, such as health, housing and food, and the public purse often cannot meet all of these. Unless other sources of finance are sought, the development of hydropower projects will be affected, with time slippages and costs overruns.

ECA supports sustainable energy development and climate resilient infrastructure

ECA provides technical support for the realisation of the goals of the Africa Union Agenda 2063, of which the PIDA is one of the flagship programmes, as well as the UN Sustainable Energy for All intiative (SE4All). The latter aims for universal access to modern energy by 2030, as well as doubling the energy derived from renewable sources, and doubling efficiency improvements of energy systems. These are in support of the Sustainable Development Goal 7 on energy. There are a number of programmes that ECA, in partnership with key stakeholders, particularly the African Union, is involved with. Most of these initiatives promote low-carbon energy development as well as innovative financing regimes for clean energy infrastructure projects.

ECA, AUC, the World Bank and the African Development Bank have teamed up and launched the 'Africa Climate Resilient Investment Facility – AFRI-RES' with initial seed funding from the Nordic Development Fund (NDF).

AFRI-RES is an Africa-based networked centre of technical competence and excellence, with the overall objective of strengthening the capacity of African institutions (including national governments, river basin organisations, regional economic communities, and power pools, among others) as well as the private sector (project developers and financiers) to plan, design, and implement infrastructure investments that are resilient to climate variability and change in selected sectors.

A central function of AFRI-RES will be to facilitate interaction between policy-makers, financiers, project developers, and scientific and engineering experts in order to develop and mainstream new practices that deliver climate-resilient infrastructure in Africa. The scope of the work of the facility would thus span different sectors and different stages of the planning and project development process.

In supporting African institutions and the private sector to strengthen their capacity to plan, design, and implement infrastructure investments that are resilient to climate variability and change in selected sectors, AFRI-RES will deliver on the following:

Component 1: Project-level technical assistance

This includes expert support to developers to draft terms of reference that include specifications for carrying out climate

Across Africa, hydropower has become the renewable energy of choice, and accounts for around 80 per cent of all non-fossil fuel use.

resilience assessments in pre-feasibility or feasibility studies, quality-assuring consultant reports, or including climate risk management actions in the structuring of public-private partnership agreements or contracts, thus providing additional support for seeking incremental financing to cover the additional costs of including climate change considerations in project design.

Component 2: Outreach, dissemination and training

AFRI-RES will undertake a range of activities to encourage behavioural change in climate-resilient investment planning. These will range from upstream work of awareness-raising (e.g. workshops, seminars) intended to enhance the understanding of public and private sector decision-makers about the risks of climate variability and change in relation to the performance of infrastructure, to more in-depth technical workshops (targeted at practitioners) to support robust decision-making, access to finance, technology transfer and capacity building, reflecting real-life experiences.

Component 3: Guidelines, standards and good practice notes for climate-resilient infrastructure investment

The facility will identify good practice and develop guidelines to inform decision-making on incorporating climate risk into infrastructure planning and design across different sectors and stages of decision-making (eg from the policy level through sector level planning to individual project design).

Component 4: Climate knowledge and data portal

The facility will develop and maintain an online repository of climate data, tools and climate information services of relevance to climate-resilient investment, planning and design in Africa. This will include a library of project-level experiences, including validated climate data, models and scenarios for Africa, as well as analytics, and learning and knowledge products to support climate-resilient infrastructure investment.

This topic was discussed at:

Achieving sustainable development goals

Sustainable, Renewable and Affordable Energy for Sarawak and Beyond

2400MW of Bakun HEP was commissioned in year 2011

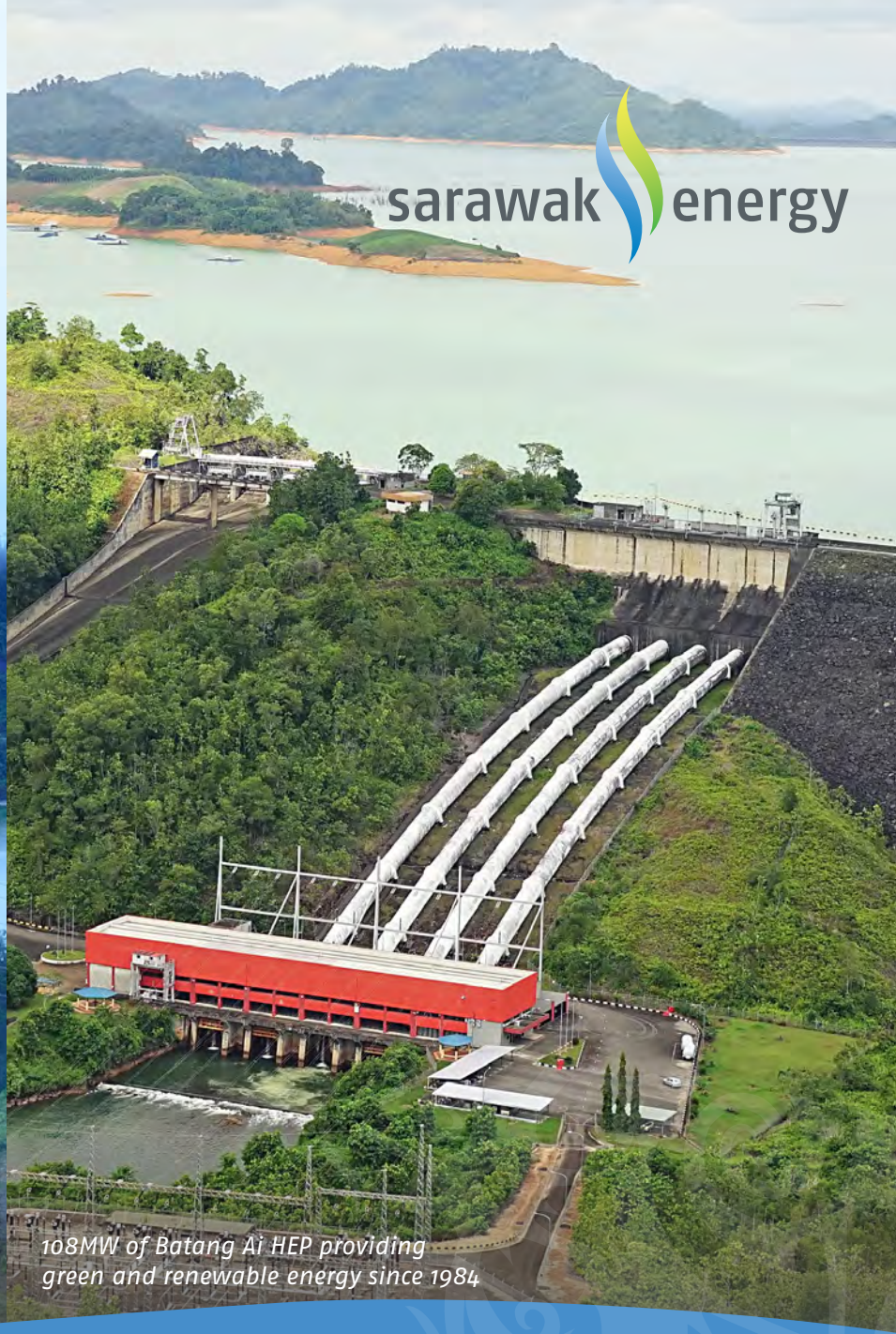
944MW of Murum HEP was officially commissioned in year 2014

Sarawak Energy is a state – owned vertically integrated electricity utility and power development company with a vision to achieve sustainable growth and prosperity for Sarawak by meeting the region's need for reliable, renewable and affordable energy.

Building on a strong foundation of 100 years as the single provider of electricity in the state, Sarawak Energy is taking bold steps to support the transformation of Sarawak in its vision to become a developed state by the year 2030.

Focused on generation, transmission, distribution and retail of electricity, Sarawak Energy generates power through hydro, coal and gas, capitalising on Sarawak's abundant indigenous resources, and supply to our customers throughout the state and beyond through an extensive network.

Power to Grow | www.sarawakenergy.com.my



108MW of Batang Ai HEP providing green and renewable energy since 1984

As the catalyst for Sarawak Corridor of Renewable Energy (SCORE), Sarawak Energy develops clean and renewable energy to power energy intensive industries, drive investments to create a stronger economy for Sarawak and its people.

Balancing the need for development with conservation, Sarawak Energy has made sustainability the foundation of its operations.

As a socially responsible corporate citizen, Sarawak Energy is powering community growth by providing sustainable livelihood programmes and is committed to partnerships that emphasise conservation of the natural environment and the rich biodiversity found in Sarawak.

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FOCUS

Long-distance transmission enabling hydropower development

Long-distance transmission infrastructure is fundamental to the delivery of hydropower generation to load centres while providing access to regional markets for the export of surplus electricity.

Transmission interconnections to countries with abundant hydropower resources provide access to low-cost, renewable electricity supply, and for developing countries, linking resources to major energy users can help to facilitate much-needed investment in the development or expansion of hydropower.

When properly planned, that investment can also benefit the local population by providing vital access to energy, driving local economic development and creating jobs.

Regional interconnections can also result in lower energy costs for trading partners, by providing access to clean and renewable energy generation.

In certain markets, it can be more advantageous to import excess hydropower than it is to build local thermal power plants. Interconnections also facilitate access to energy storage, balancing variable generation sources like wind power and solar PV in neighbouring countries.

In many countries, vast quantities of hydropower potential can be economically developed to serve regional demand for clean, reliable, low-cost electricity. However, development of these resources often relies on long-distance transmission facilities, connecting the hydropower resource to major load centres. This can be challenging, particularly where the load centre is located a significant distance from the generation source.

Global energy interconnections

The concept of 'global energy interconnection' is one of the latest trends towards the development of ultra-high-voltage (UHV), long-distance interconnections, at regional and intercontinental scales to enable the growth in renewable energy technologies required to meet global energy demand.

The Global Energy Interconnection Development and Cooperation Organization (GEIDCO) sets out a roadmap in its white paper on global energy interconnection development strategy. The roadmap is divided into three phases:

- Domestic: up to 2020, countries will focus on their own clean energy and grid interconnection projects.
- Intracontinental: by 2030, large-scale energy bases and cross-border grid interconnections will be promoted within each continent.
- Intercontinental: by 2050, energy bases of the Arctic and equatorial regions and intercontinental interconnection will be set up. Global energy interconnection will effectively come into being.

Discussions are already underway among major energy companies in China, Japan, Russia and South Korea around the creation of an 'Asian Super Grid', in which a UHV grid would link electrical grids across regions, countries and continents to transmit electricity generated with an abundance of clean, renewable sources like hydropower.

The following sections describe examples of long-distance UHV transmission either in service today or in planning, which will form the backbone of GEIDCO's concept of a globally interconnected world.

China

China has roughly 331 GW of hydropower installed, with the potential to develop an additional 200 GW. However, this potential can only be realised with the support of interconnections and UHV electricity lines in operation.

The Asian Super Grid is a concept contingent on UHV power transmission lines, over long distances, operating at more than 1,000 kV AC / 800 kV DC, connecting China, South Korea, Russia and Japan.

Since 2009, China has built nearly 16,000 km of UHV power lines and is aiming to increase the total length of its high-voltage transmission lines to 1.01 million km by the end of 2020.

The State Grid Corporation of China, the largest electric utility company in the world, has stated that it will invest roughly USD 88 billion into UHV transmission development between now and 2020.

Canada: Manitoba–Minnesota interconnection

In Canada, the predominantly hydro-based provinces of Manitoba, British Columbia and Quebec are increasing their already strong interconnections with the neighbouring grids of the US Midwest.

Utilities like Manitoba Hydro can utilise their hydropower reservoirs to balance the output of major windfarm developments to the south, while enabling bilateral trade opportunities for export and providing import capability for reliability in low-water conditions.

To take advantage of future export and import opportunities, Manitoba Hydro and Minnesota Power are cooperating on building a new 500 kV interconnection between Canada

and the United States. The line is anticipated to enter service in 2020, coincident with the in-service date of the first new hydropower station at Keeyask (695 MW).

The existing interconnections to the USA have a capability of 2,000 MW. Building the new interconnection will increase that capacity to almost 3,000 MW, giving Manitoba Hydro the ability to concentrate the delivery of surplus energy during on-peak hours rather than in off-peak hours.

South and Central Asia: CASA-1000

Kyrgyzstan and Tajikistan are two countries in Central Asia endowed with some of the world's most abundant clean hydropower resources, with water cascading from the mountain ranges and filling the rivers every summer. Both of these countries have a surplus of electricity during the summer.

Nearby South Asia, Afghanistan and Pakistan suffer from chronic electricity supply shortages while trying to keep pace with fast-growing demand. Pakistan cannot meet its citizens' electricity needs, especially during the sweltering summer months, leading to frequent power cuts that hurt industrial production, sometimes close small businesses, and lead to job losses. Meanwhile, millions of people still live without electricity altogether.

CASA-1000, a new electricity transmission system to connect all four countries, would help make the most efficient use of clean hydropower resources in the Central Asian countries by enabling them to transfer and sell their electricity surplus during the summer months to the deficient countries in South Asia. The CASA-1000 project would also complement the countries' efforts to improve electricity access, integrate and expand markets to increase trade, and find sustainable solutions to water resources management.

Eastern African Power Pool (EAPP)

In East Africa, more than 200 million people are without electricity, accounting for around 80 per cent of its population.

Ethiopia, Kenya and Uganda are among the most populous countries in the region, and have the largest populations both with and without access to electricity.

East Africa, much like the rest of Africa, exhibits a diverse range of economic and energy sector development. Regional interconnections have the potential to enable hydropower development in East Africa.

In order to meet the rapidly growing electricity demand, African governments have collectively recognised the need for effective and integrated regional planning and interconnections.

While bilateral agreements exist between some neighbouring jurisdictions in the EAPP, power exchange over existing regional interconnections has not been optimised, and is often marred by failed contractual obligations due to local system deficits.

A master plan for the EAPP was derived using existing national power development strategies. The original master plan published in 2011 estimated that with a USD 4.5 billion investment in interconnections, USD 25 billion in net revenue could potentially be generated through increased opportunities for power trading, as compared to individual national development programmes.

In many countries, vast quantities of hydropower potential can be economically developed to serve regional demand for clean, reliable, low-cost electricity.

By optimising generation investments away from fossil fuels and towards hydropower supply, the net benefit increased to USD 32 billion.

Cross-border interconnections between the countries of the EAPP reduce fuel costs, while improving the security of energy supply in the system, enabling countries to optimise domestic energy sources and compensate for potential seasonal variability or fuel shortages. For example, regional interconnections could mitigate ongoing natural supply problems in Egypt or inadequate distribution systems in Ethiopia.

To incentivise the development of regional interconnections in East Africa, there are a number of issues that must be addressed:

- Removing the up-front risk to private investment by ensuring that projects are configured for optimal system and national benefit, and that the selected projects are the most appropriate for national development.
- Fostering greater regional cooperation between local and national governments.
- Implementing better policy for incentivising regional development, cross-border energy sharing and reduced regulatory risk.

This article originally appeared in the 2017 Hydropower Status Report, available to download at www.hydropower.org/status

This topic was discussed at:

Hydropower and long-distance transmission

中国电建 POWERCHINA | 中国水电 SINOHYDRO

BUILDING A SUS

POWERCHINA is an integrated GLOBAL construction group that provides COMPLETE EPC SUPPORT AND SERVICES COMPRISING investment & financing, planning, design, construction, procurement, equipment manufacturing, operation and maintenance, management for water, hydropower and infrastructure projects. Its CORE businesses FOCUS UPON energy & power and construction engineering, water ecological environmental governance, development and operation of other resources, real estate development and operation, lease of related equipment. POWERCHINA SPECIALIZES IN LEADING EDGE INNOVATIVE TECHNOLOGIES THAT MAXIMIZE SUSTAINABLE EFFICIENT ENVIRONMENTAL AND TECHNICAL BENEFITS.

SINOHYDRO is the key international brand of POWERCHINA Corporation. It is renowned as China's first brand in hydropower construction in Africa.

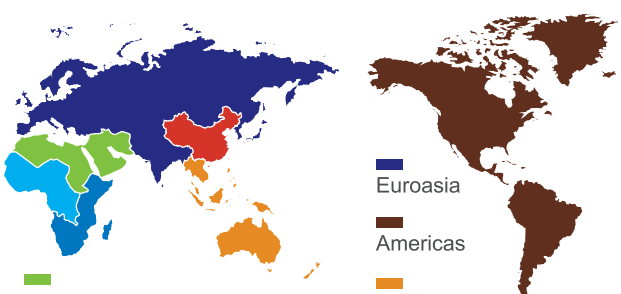
Other Overseas Brands

中国水电顾问 HYDROCHINA | sepco III 山东电建 | SEPCO 山东电建

ENR 2016

- 200 The Fortune 500 Enterprises
- 2 The Top 150 Global Design Firms
- 6 The Top 250 Global Contractors
- 11 The Top 250 International Contractors
- 27 The Top 225 International Design Firms

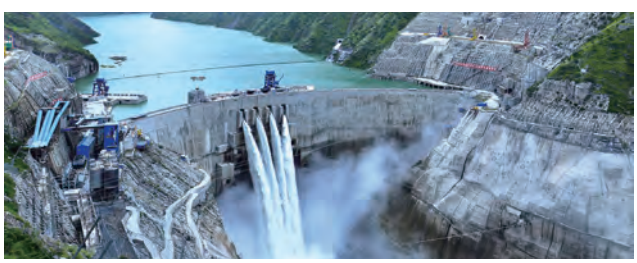
Regional Offices



Yangtze Three Gorges Water Conservancy Project (22

Phase 1 of Middle Route Project of South-to-North Water Diversion, China

Kariba North Hydropower Station, Zambia, Zimbabwe



The Jinping-I Dam(Height 305m,3600MW), China

Karuma Hydropower Station, Uganda

STAINABLE FUTURE FOR AFRICA

2,400MW), China

Coca Codo Sinclair Hydropower Project (1500MW), Ecuador

Nam Ou River Cascade Project, Laos

Djiploho Hydropower Plant, Equatorial Guinea

Bui Hydropower Station(400MW), Ghana

Merowe Dam Project (Height 114, 1250MW), Sudan

Padma Multipurpose Bridge Project - River Training Works, Bangladesh

Bakun CFRD Dam (Height 205m, 2400MW), Malaysia

Dongfu Island Wind/Photovoltaic/Diesel/Storage and Sea Water Desalination System Project, China

Tekeze Dam (Height 185m, 300MW), Ethiopia

FOCUS

Better managing risk to scale up the development of sustainable hydropower

There is growing interest in the establishment of a facility to support hydropower project preparation and bridge a widening financing gap. The World Bank, the Global Infrastructure Facility (GIF), and the New Partnership for Africa's Development Infrastructure Project Preparation Facility (NEPAD-IPPF) discuss the proposed 'Hydropower Preparation Support Facility'.

The world is undergoing a colossal shift in the way energy is being produced, delivered and consumed. According to the International Energy Agency, global energy demand will increase by around 30 per cent by 2040, with renewables accounting for the lion's share of the increase. However, even this picture masks the pace of change taking place in developing countries throughout Africa and Asia, as these regions seek to address acute forms of energy poverty and achieve the trilemma of affordable, reliable and clean energy.

Untapped potential

Hydropower, delivering on all its multipurpose benefits, can be a powerful tool to aid countries in their transition and development. However, due in part to the risks associated with its complex and lengthy project preparation work, hydropower remains largely underutilised in these key regions experiencing power shortages. Therefore, mitigating the risks involved in the preparation phase of a project's development must remain a key priority for the sector.

Nowhere is the challenge of improving basic energy services more formidable than in sub-Saharan Africa, where over 600 million people live without reliable access to electricity, and many more are reliant on solid biomass to cook their food and heat their homes.

The region has the lowest electricity generation capacity despite having abundant energy resources, including substantial hydropower potential, which can provide grid stability, energy storage and flexibility for balancing clean energy systems that comprise an increasing proportion of variable renewable energy sources. To put this into perspective, while Europe and Africa have similar hydropower potentials, Europe has an installed capacity of 223 GW, while Africa only utilises 34 GW.

Mitigating risks during preparation

As governments in developing countries seek to address their generation capacity shortages alongside other infrastructural and development needs, their national budgets fall well short of what they need. As a consequence, there is a large need to attract private investment, particularly for priority infrastructure needs. Attracting large amounts of commercial finance for large hydropower is challenging the world over, and particularly for countries with lower credit ratings.

A significant barrier that remains to private sector investment, though, is the financial risk associated with rigorous hydropower project preparation, complex approval processes, community negotiations, land acquisition and so on, prior to there being certainty that the project will proceed. This has curtailed development and led to a growing interest in the establishment of a facility to support hydropower project preparation and help bridge this growing financing gap.

Known as the Hydropower Preparation Support Facility (HPSF), it would aim to optimise private sector investment

by managing a fund to support the selection of the most appropriate project type and location according to the local or regional context.

Through public-private collaboration, selected projects would be prepared by incorporating international good practices, working closely with local stakeholders in a methodical manner to produce specific project blueprints.

By focusing support on the preparation phase of a project's lifecycle, where the financial risk is at its highest, the fund will better align the risk-reward profile for both host countries and project developers.

Crucially, the facility would operate on a cost-recovery basis as the blueprints, along with the necessary project approvals, would be auctioned for development. As a result, the developer would pay for the project preparation, but without the risk of the project not being approved. The auctioned funds would be returned to the HPSF to repeat the cycle for future projects without the host country incurring significant costs.

Project blueprints developed to international industry good practice via the facility would also have the potential to access additional sources of project financing throughout its long lifecycle, including the growing green bond market, which reached a record USD 81 billion in issuances in 2016.

Delivering multiple benefits

In addition, by leveraging private sector investment in sustainable, cost-efficient, system-supporting hydropower, the facility would assist developing countries in achieving the energy trilemma and addressing the crippling energy deficits which stifle economic growth and job creation.

The ability of hydropower to store and manage water can help transform a region's agricultural capacity, provide clean drinking water, increase climate resilience and create secondary industries through the recreational opportunities it can deliver.

Given the scale and generating capacity of many hydropower projects, their benefits can be delivered across borders, with regional interconnectors becoming an indispensable ingredient in developing reliable and accessible electricity markets.

Growing momentum

Building on the work carried out by similar mechanisms such as the Geothermal Risk Mitigation Facility for Eastern Africa (GRMF), the Global Infrastructure Facility (GIF) and the New Partnership for Africa's Development Infrastructure Project Preparation Facility (NEPAD-IPPF), the HPSF could be developed quickly and would have the flexibility to operate within existing structures.

The concept has already received interest from a number of national governments, financial institutions, development agencies and leaders from hydropower developers.

William Rex, global lead for hydropower and dams at the World Bank, sees the facility as an important opportunity to shape and accelerate the development of sustainable hydropower.

He said: "Hydropower is a natural fit for many developing countries, as they grapple with not only meeting rising energy demand, but also water demand and the need for sufficient water storage capabilities.

There needs to be a multisectoral approach to the development of hydropower projects, and facilities to support upstream planning and project development could be very helpful in promoting integrated approaches. The proposed Hydropower Preparation Support Facility could help by attracting private sector finance for projects that are built in the right place, in the right way."

It is important that the Hydropower Preparation Support Facility complements and builds on the lessons from other infrastructure financing efforts. To this end, Jason Zhengrong Lu, acting head of GIF, will participate in the plenary session on the HPSF.

Established in 2015, GIF is a partnership among governments, multilateral development banks, private sector investors and financiers designed to collaborate, prepare, structure and implement complex infrastructure projects in emerging and developing countries. With a wealth of experience in infrastructure project financing, including in the hydropower sector, Jason Zhengrong Lu has seen the importance of project preparation facilities for complex infrastructure projects.

"There is a strong public interest in developing an approach that mitigates the risks inherent in the early stages of infrastructure projects."

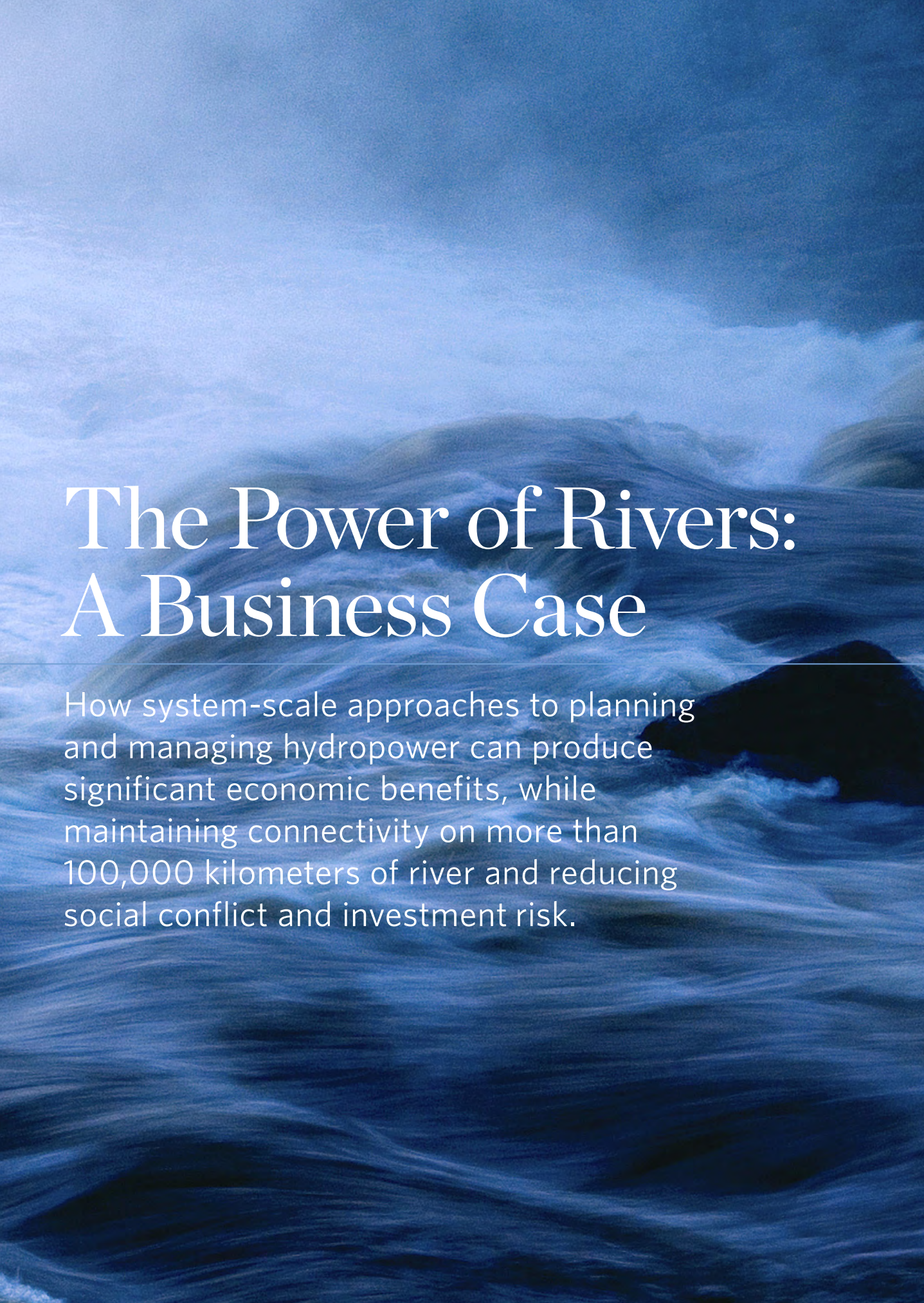
He said: "There is a strong public interest in developing an approach that mitigates the risks inherent in the early stages of infrastructure projects. By doing so, you can unlock private sector investment and deliver bankable, self-sustaining projects that meet the needs of governments and society as a whole."

As the president of the African Development Bank Group, Akinwumi Adesina has said, "no development can occur in the dark". The energy challenge for Africa is immense, and hydropower as a clean, reliable, low-cost form of electricity has a significant role to play in meeting it. The HPSF can help make this happen.

In addition to the World Bank, NEPAD-IPPF and GIF, the 2017 World Hydropower Congress brings together high-level representatives from POWERCHINA, the International Hydropower Association (IHA) and African governments to discuss the concept, the lessons that can be learnt from similar facilities, and how it can be taken forward to scale up the development of sustainable hydropower in key regions.

This topic was also discussed at:

Hydropower Preparation Support Facility



The Power of Rivers: A Business Case

How system-scale approaches to planning and managing hydropower can produce significant economic benefits, while maintaining connectivity on more than 100,000 kilometers of river and reducing social conflict and investment risk.

PHOTO © BRIDGET BESAW

DOWNLOAD THE REPORT AT

nature.org/powerofrivers

The Nature Conservancy

Session reports

Over the three days in Addis Ababa, participants in the 2017 World Hydropower Congress charted the course for hydropower's role in delivering a new, resilient, clean energy mix and responsible freshwater management for all.

Opening plenary

Co-convenors

African Union Commission

Global Energy Interconnection Development and Cooperation Organization

Global Energy Interconnection Development and Cooperation Organization
全球能源互联网发展合作组织

The opening session of the 2017 World Hydropower Congress addressed two themes: achieving sustainable development goals and the realisation of an interconnected world.

The UN Sustainable Development Goals and the Paris Agreement provided a powerful backdrop to the 2017 World Hydropower Congress.

In this high-level opening session, speakers from governments, international institutions and businesses shared their insights into achieving universal access to reliable, sustainable and modern energy for all.

They considered the vital role hydropower will play in this sustainable energy transition, and the potential for tapping into vast renewable resources around the world.

Profound changes in the ways people use and produce energy are underway, and ambitious programmes are increasing the contribution of renewables and impacting on infrastructure planning.

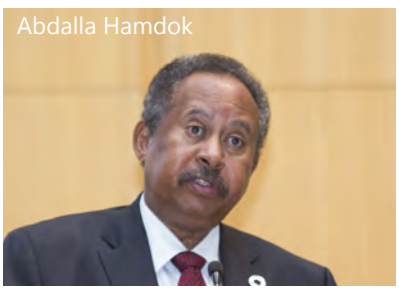
Speakers

- **Hailemariam Desalegn,** Prime Minister of Ethiopia
- **Abdalla Hamdok,** Executive Secretary (ag.), United Nations Economic Commission for Africa (UNECA)
- **Quartey Thomas Kwesi,** Deputy Chairperson, African Union Commission
- **Liu Zhenya,** Chairman, Global Energy Interconnection Development and Cooperation Organization (GEIDCO)
- **Ken Adams,** President, International Hydropower Association (IHA)
- **Rachel Kyte,** CEO, Sustainable Energy for All (SE4All)
- **Alice Jawan Empaling,** Permanent Secretary to the Minister of Public Utilities, Government of Sarawak
- **Wang Lin,** President, China Three Gorges Corporation
- **Han Jun,** Executive Vice President, State Grid Corporation of China
- **Lucio Monari,** Director, Energy and Extractives Global Practice, World Bank Group
- **Chen Guanfu,** Executive Vice President, POWERCHINA
- **Evgeny Olkhovich,** Deputy General Manager, PJSC Rosseti

Opening the session, Hailemariam Desalegn stated that development in Africa is 'unthinkable' in the absence of affordable energy, warning that the continent will not be on course to meet the 17 Sustainable Development Goals without universal access to electricity.


Hailemariam Desalegn

The UN Sustainable Development Goals and the Paris Agreement provided a powerful backdrop to the 2017 World Hydropower Congress.


Abdalla Hamdok

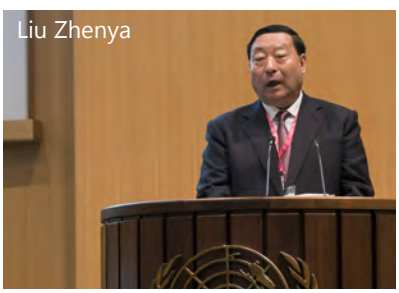
Large international initiatives such as the Global Energy Interconnection Development and Cooperation Organization (GEIDCO), an organising partner of the congress, and Sustainable Energy for All (SE4All), will be critical to delivering on the global climate and energy goals.

GEIDCO, launched by Chinese president Xi Jinping in 2015, has the ambitious vision of delivering a fully integrated and interconnected global energy system.

Speakers shared their perspectives on how this vision could take shape, and what steps are needed to realise a truly sustainable, interconnected, accessible, reliable, clean and affordable energy system for all.

Key discussion points

Opening the session, Hailemariam Desalegn stated that development in Africa is "unthinkable" in the absence affordable energy. He warned that the continent will not be on course to meet the 17 Sustainable Development Goals (SDGs) without universal access to electricity.


Liu Zhenya

Strong and coherent policies are needed to promote faster and more inclusive growth through the optimal use of hydropower and other renewables, according to Abdalla Hamdok of UNECA. He described some of the initiatives UNECA is working on together with the AUC to promote low-carbon energy development and innovative financing regimes for clean energy infrastructure in Africa. Representing AUC, Quartey Thomas Kwesi gave an overview of Africa's plans to address its energy challenges under the Programme for Infrastructure and Development (PIDA), emphasising the critical role hydropower will play in this process.

Global interconnection is essential to exploit the world's untapped renewable


Aline Jawan Empaling

resources, said Liu Zhenya, pointing to its potential to connect resource-rich areas with long-distance power load centres. Africa, in particular, could benefit from greater interconnection in order to exploit its vast, but largely untapped, natural resources. He explained that the world's abundant clean energy resources are distributed unevenly, and as such many remain unexploited. However, new technologies are making the vision for a truly interconnected world increasingly achievable, and coupled with falling clean energy costs, interconnection on a global scale could be key to meeting the world's climate and energy challenges.

Offering the perspective of Sarawak, a state rich in hydropower potential, Alice Jawan Empaling described plans to exploit the as yet largely untapped natural resources, and to share these with neighbouring countries. Sarawak has had a power sharing agreement in place with Indonesia since 2013, with others planned or in development. Progress in developing Sarawak's hydropower sector is also set to make a major contribution to the ASEAN power grid.

Rachel Kyte pointed out that sustainable hydropower has a critical role to play in achieving the SDGs and meeting the commitments of the Paris Agreement. In particular, she emphasised hydropower's storage capabilities, which can support the growth of variable renewable sources such as wind and solar.


Rachel Kyte


Lucio Monari

Rachel Kyte said we must "move forward with speed and scale", and hoped the congress would serve as a catalyst to "spur rapid progress" towards meeting the challenge of securing sustainable energy for all by 2030.

Greater collaboration is essential for achieving global climate and energy goals, said IHA President Ken Adams, commenting that "hydropower is not done in isolation". He called for more cooperation between institutions, governments and businesses.

Key outcomes

The overall message from the discussions was the need for greater collaboration.

Speakers called for collective efforts to address global climate and energy challenges, with Hailemariam Desalegn saying the "world must pull together".

Mr Adams warned that achieving the SDGs "will not be possible without breaking barriers and widening the scope of collaboration between all partners and institutions", while Liu Zhenya stressed the need for coordinated policies, communication and consent to drive an interconnected world.

Speakers stressed the urgency of the situation: Abdalla Hamdok noted that 600 million people in Africa currently live without electricity, yet the continent "has the potential to take the lead in innovation, technologies and business models that utilise hydropower optimally and efficiently".

Quartey Thomas Kweti agreed that the development and expansion of renewable energies is one of the most effective strategies to promote development, sustainable energy access and energy security, and to mitigate climate change at global, continental and regional levels.


Wang Lin

Acknowledging the central role hydropower will play in the sustainable energy transition, Rachel Kyte said we must "move forward with speed and scale", and hoped the congress would serve as a catalyst to "spur rapid progress" towards meeting the challenge of securing sustainable energy for all by 2030.

Global energy interconnection (GEI) will be critical to accelerating the low-carbon energy transition, and can make a particular difference in Africa, where vast renewable resources remain untapped. Liu Zhenya stated that in order to realise the potential of GEI, we need more coordinated policies and better communication and common consent. Addressing the potential for interconnection in Africa, he called for concerted efforts from all African nations and stressed the importance of leveraging the influence of organisations such as UNECA, AUC and IHA for building a community of stakeholders committed to sustainable energy and interconnectivity.

Water security for all

Co-convenor
African Ministers' Council on Water

Freshwater management is a major societal challenge, especially in developing economies. It is also becoming increasingly difficult due to the impacts of climate change.

Hydropower infrastructure is capable of storing water, setting it apart from other renewable technologies.

Hydropower's storage capabilities enable it to provide climate adaptation services to mitigate the impacts of extreme weather events, such as prolonged drought and significant flood events.

At the crossroads of the water and energy nexus, hydropower can serve as the driver for the development of more multipurpose reservoirs. It therefore has the potential to play a fundamental role in achieving most of the UN Sustainable Development Goals (SDGs), in particular ensuring availability and sustainable management of water for all.

The session addressed questions such as: do current policies provide an adequate framework to respond to the challenges of sustainable water management and achieve the SDGs? How can hard and soft infrastructure work together to deliver water services?

Representatives from governments, business and civil society organisations discussed the challenges they face and shared ideas and solutions based on proven good practices and success stories from around the world.

Speakers

- **Ahmed Bahaa Eldin,** Chair of Nile Water Sector, Ministry of Water Resources and Irrigation, Arab Republic of Egypt
- **Seleshi Bekele,** Minister of Water, Irrigation and Electricity, Federal Democratic Republic of Ethiopia
- **Giulio Boccaletti,** Chief Strategy Officer and Global Managing Director for Water, The Nature Conservancy
- **Canisius Kanangire,** Executive Secretary, African Ministers' Council on Water
- **Josefa Leonel Correia Sacko,** Commissioner for Rural Economy and Agriculture, African Union Commission
- **Yves Rannou,** President and CEO, Hydro, GE Renewables (moderator)

"Without water access, there is no prosperity, there is no water security."
- **Seleshi Bekele,** Minister of Water, Irrigation and Electricity, Federal Democratic Republic of Ethiopia

Seleshi Bekele

Hydropower has the capability to manage freshwater resources sustainably, foster economic development and conserve ecosystems.

Ahmed Bahaa Eldin

Key discussion points

In her opening address, Josefa Sacko made the case for inclusive growth in Africa, and the need to capitalise on the potential of its people, in particular women and young people. The African Union Commission (AUC) collaborates with the African Ministers' Council on Water (AMCOW) in the areas of agriculture and rural development, water and the environment.

AMCOW has developed a set of common indicators to monitor progress on water quality and sanitation. These indicators are reported on periodically at African Union summits to facilitate informed and evidence-based policy decisions.

AUC's many partners range from river basin organisations, like the Nile Basin Initiative, to financial institutions such as the World Bank Group, and international agencies, including UN Water and the UN Food and Agriculture Organization (FAO).

The main challenges for water security include a lack of appropriate policies and regulatory framework, inadequate capacity for information management, and limited funds.


Giulio Boccaletti

AUC is committed to engaging with all parties to address these challenges and achieve the African Water Vision 2025, Africa's Agenda 2063 and the UN SDGs.

Giulio Boccaletti followed with an introductory address on the important role hydropower can play in adapting to climate change and improving water security, with a view to achieving SDG 6 ('ensure availability and sustainable management of water and sanitation for all').

Hydropower has the capability to manage freshwater resources sustainably, foster economic development and conserve ecosystems. Hydropower's related infrastructure, institutions and management together have a critical role to play in finding the optimal solutions.

Josefa Sacko

With this in mind, The Nature Conservancy has developed the 'Hydropower by Design' concept, a strategic portfolio approach to allow energy production while maintaining vital river functions.

Acknowledging the need for a paradigm shift, the approach emphasises that hydropower cannot be developed in isolation, and requires optimisation and investment in better portfolios.

Representing AMCOW, Canisius Kanangire stressed that water-related disaster and water risks must be managed. Good governance and decision-making need to be in place in order to implement water for all.

He emphasised that transboundary waters can be a source of conflict but also of cooperation, in cases where both the cost of development and the benefits are shared. He also pointed out that development of infrastructure boosts resilience.

Ahmed Bahaa Eldin described the severe water challenges faced by Egypt, due to a lack of infrastructure to mitigate the impacts of extreme drought.

With its growing population and increasing water demand, Egypt is facing a water deficit. As such, it is having to tap into alternative water sources, such as groundwater and wastewater.


Yves Rannou

There is limited understanding of hydropower's contribution to water supply and security, in particular when it comes to hydropower's water footprint and the mitigation of risks.

Cooperation is essential, and he explained that cooperation and trust between riparian countries can open new opportunities and be a win-win situation when benefits are shared.

Seleshi Bekele highlighted that water security is not simply about the quantity of water, but also quality. Water security is also intrinsically linked to vulnerability.

Hydropower developments can deliver many benefits, particularly in terms of managing the impact of extreme climate events such as El Niño o La Niña.

With the appropriate policies and institutions, hydropower development can address security concerns around climate variability and related risks, including water quality.

Sustainable water resource management needs to take into consideration transboundary and environmental aspects, such as good governance and equity.

Mr Bekele explained that multipurpose projects can deliver many benefits. He gave the example of the Grand Ethiopian Renaissance dam (GERD), which manages sediments and water upstream, to the benefit of countries downstream.

Mr Bekele concluded by stating that: "Without water access, there is no prosperity, there is no water security".


Canisius Kanangire

Conclusions

Hydropower has a major role to play in adapting to climate change and improving water security to contribute to SDG 6.

When the costs of development and the benefits are shared, transboundary waters can also be a source of cooperation.

With this in mind, the development of monitoring and reporting systems with common indicators on water and sanitation can facilitate cooperation and evidence-based policy decisions.

The main challenges that remain include a lack of appropriate policies and regulatory framework, an inadequate capacity for information management and limited funding.

What next?

Building on the session, IHA will work to ensure water is valued appropriately.

There is limited understanding of hydropower's contribution to water supply and security, in particular when it comes to hydropower's water footprint and the mitigation of risks.

In times of drought, access to water becomes more valued, and during floods controlling excess water is critical.

This is even more relevant when taking into account that changes in hydrological patterns are increasingly expected.

IHA's strategic priority will be to develop an accepted framework for reporting on hydropower's net water footprint, taking into account the multiple uses of a reservoir and the interseasonal value of water.

The framework will be developed in cooperation with the relevant IHA knowledge network and expert group.

Hydropower Preparation Support Facility

Co-convenor
World Bank Group

WORLD BANK GROUP

Properly planned hydropower projects can perform multiple roles, providing a variety of benefits, and early-stage project preparation is key to unlocking them.

Properly planned hydropower projects can provide grid stability, energy storage and flexibility for balancing more variable renewable energy sources.

In addition, hydropower has an important role to play in meeting national emissions reduction targets to mitigate climate change, as well as providing flood protection through drought management.

Bringing together government ministers, financial institutions and leaders from the private sector, this session explored the proposal for a project preparation tool, the 'Hydropower Preparation Support Facility' (HPSF).

Such a facility would manage a revolving fund which would leverage investment in sustainable, system-supporting hydropower in targeted countries and regions where hydropower is currently under-utilised, such as in Africa.

Supporting early-stage project planning by providing blueprints for the optimal development of specific projects, the facility would help ensure the right projects are built in the right place.

Speakers

- **Chen Guanfu,** Executive Vice President, POWERCHINA
- **Jason Zhengrong Lu,** Acting Head, Global Infrastructure Facility
- **Irene Muloni,** Minister of Energy and Mineral Development, Uganda
- **Israel Phiri,** Independent Consultant
- **Shem Simuyemba,** Division Manager, New Partnership for Africa's Development - Infrastructure Project Preparation Facility (NEPAD-IPPF)
- **Jie Tang,** Practice Manager, Energy and Extractives Global Practices, East Asia and Pacific, World Bank Group
- **Richard Taylor,** CEO, International Hydropower Association (IHA; moderator)

"There is a need for the Hydropower Preparation Support Facility to develop projects that deliver energy at low cost and in a sustainable manner." - **Irene Muloni,** Minister for Energy and Mineral Development, Uganda


Irene Muloni

Governments are looking to attract multiple developers to drive competition, while developers are searching for bankable projects with appropriate risk profiles.

Richard Taylor

In doing so, the blueprints would also reduce the financial risk associated with hydropower project preparation for private sector developers and investors, as projects would be ready for implementation with the necessary approvals already in place.

Key discussion points

Richard Taylor introduced the concept of the Hydropower Preparation Support Facility. He noted the objectives and benefits such a facility could provide both to the private sector and the host government, by ensuring a system-scale approach is taken to hydropower project planning.

Irene Muloni gave an overview of the Ugandan electricity sector, which is comprised of 85 per cent renewables. She commented in particular on the role of hydropower in the sector, with the Karuma and Isimba hydropower plants due to be commissioned in 2018.

Chen Guanfu

Stressing the importance of the preparation stage for hydropower development, Ms Muloni stated that: "Assessing the risk is very pertinent in Uganda at the moment."

According to Ms Muloni, there are two main risks for hydropower development. Firstly, the country risk: the issue of political and economic instability. Secondly, the financial risk, due to the capital-intensive nature of projects, with high-risk projects demanding a high return, which impacts on the pricing of the electricity.


Jason Zhengrong Lu

Expressing her support for the facility, Ms Muloni said: "There is a need for the HPSF to develop projects that deliver energy at low cost and in a sustainable manner."

Jie Tang, Jason Zhengrong Lu, Israel Phiri and Chen Guanfu all acknowledged that the facility could help bridge the annual USD 1-1.5tn infrastructure financing gap that exists in low and middle income countries through to 2020.

They also recognised that there is an increasing role for the private sector to play, as finite public sector finances are prioritised in other areas, such as health and education.

Governments are looking to attract multiple developers to drive competition, while developers are searching for bankable projects with appropriate risk profiles.

The facility could play an important role in improving a project's risk-reward profile by focusing its support on the key preparatory stage of development.

Shem Simuyemba introduced the facilities that the African Development Bank already operates, notably the New Partnership for Africa's Development - Infrastructure Project Preparation Facility (NEPAD-IPPF), and the Sustainable Energy Fund for Africa (SEFA). To date, these facilities have returned USD 80-100 of private sector investment for every USD 1 of publicly-invested funds.


Shem Simuyemba


Jie Tang

A common theme throughout the discussions was that 'the best risk reduction strategy is the best project preparation'.

Mr Simuyemba pointed out that for the HPSF to be a success, it needs to make clear its specific value, which is the provision of a total solution, a multi-sectoral approach to hydropower development.

Key outcomes

In summarising the discussions and presenting their key messages, the panellists expressed strong support for the facility.

They emphasised the need to establish a steering group, and stressed the importance of ensuring governments, private sector investors and civil society are all fully engaged and willing to be involved in the facility's development.

A common theme throughout the discussions was 'the best risk reduction strategy is the best project preparation'.

Israel Phiri

What next?

The outcomes and next steps of the session will include IHA preparing the structure, remit and composition of the proposed steering committee. The committee will be responsible for taking the concept forward and providing guidance as to how the facility could be funded and its optimal operating model. Alongside this, IHA is continuing discussions with relevant stakeholders, including national governments, financial institutions and developers to build support for the concept and help identify a proof of concept project.

Hydropower and interconnections in Africa

Co-convenors

Global Energy Interconnection Development and Cooperation Organization (GEIDCO)

Infrastructure Consortium for Africa (ICA)

Global Energy Interconnection Development and Cooperation Organization
全球能源互联网发展合作组织

ICA The Infrastructure Consortium for Africa

Driven by the Programme for Infrastructure Development in Africa (PIDA) and the UN's Agenda 2063, electricity infrastructure, transmission, interconnections and hydropower are simultaneously undergoing considerable development throughout the African continent.

Currently, the significant deficit in Africa's infrastructure is resulting in increased production and transaction costs, reduced competitiveness of businesses, and is having a negative impact on foreign direct investment flows to the continent. This is hindering the rate of economic and social development throughout the continent.

By improving the access to integrated regional and continental infrastructure networks and services, and by facilitating the increased use of renewable energy sources such as hydropower, the overall goal is to promote socio-economic development and poverty reduction in Africa.

Speakers

- **Lebbi M. Changullah,** Secretary General, Eastern Africa Power Pool (EAPP)
- **Callixte Kambanda,** Chief Infrastructure Specialist, Infrastructure Consortium for Africa (ICA)
- **Li Li,** President, China International Water & Electric Corporation
- **Liang Xuming,** Chief Engineer, Global Energy Interconnection Development and Cooperation Organization (GEIDCO)
- **Wu Weining,** Vice President, NARI Group Corporation
- **Lei Xiangzhang,** Director General, State Grid China Corporation European Representative Office (moderator)

The Programme for Infrastructure Development in Africa (PIDA) estimated that regional integration would save around USD 33bn by 2040 in power generation costs and would increase the demand growth by 7 per cent.


Lei Xiangzhang


Li Li


Lebbi M. Changullah

This session focused on developing a vision for Africa's electricity infrastructure based on: strategic objectives; sector policies; and prioritised regional and continental infrastructure investment programmes and mechanisms for the further implementation of hydropower and interconnections.

Panellists representing key regional and international players brought forward current hydropower and interconnection cases in Africa.

The panellists made recommendations and suggested priorities in these fields, and identified potential solutions to the challenges facing the sector, over the short, medium and long term.

Key discussion points

The speakers commented that Africa's economies have developed rapidly over recent years.

Liang Xuming explained the research that GEIDCO has carried out on Africa's energy interconnection planning, analysing energy and power development, clean energy development and utilisation, and other issues, towards achieving a green, low-carbon, clean and sustainable energy supply.


Callixte Kambanda

GEIDCO proposed an African grid interconnection pattern and five regional power pool grid planning schemes, and also assessed the technical feasibility and comprehensive economic benefits of building African energy interconnections.

Callixte Kambanda introduced ICA's 2016 'Regional Power Status in African Power Pools Report', which notes very low rural electrification rates in 2013, eg Central African Republic (1 per cent), Chad (1 per cent), Burundi (2 per cent), Democratic Republic of Congo (2 per cent). One of the key reasons behind these low rates is a lack of regional interconnectors.

It was also pointed out that while global hydropower development is very mature, by comparison Africa is lagging behind.

Africa has abundant hydropower, wind and solar power resources, yet still suffers from electricity shortages.

It was suggested that mini-grids should be constructed with hydropower as the regulation core, which could then be combined with widely-distributed wind and solar generation facilities.

Hydro-PV-wind hybrid generation built on the basis of micro-grids could be an efficient solution to improving electricity access, and the starting point for a long-term evolution of micro-grid, local grid, regional grid and eventually African continental grid development.

Key outcomes

The PIDA estimated that regional integration would save around USD 33bn by 2040 in power generation costs and would increase the demand growth by 7 per cent. Currently, electricity infrastructure, transmission, interconnections and hydropower development are in a transitional phase, with promising future development plans.

It was discussed that the hydropower industry must continue to work alongside other energy industries, such as the solar and wind sectors, to develop infrastructure, transmission lines and interconnections in order to fully open up the potential for energy access, and enhance overall economic and social development throughout Africa.


Liang Xuming

Further financial programmes/ mechanisms are also required in Africa to attract the higher levels of foreign investment needed to develop hydropower projects and improve regional interconnections. Further interconnections and the development of power pools would also boost market competition between African utilities.

What next?

The link between hydropower and interconnections development in Africa will continue to be explored through briefings and reporting by IHA. Members active in Africa are involved in regional development and the association will support communications on this topic.

IHA will also continue to work with regional and international bodies to share knowledge with operators and developers who have faced interconnection challenges in other parts of the world.

Greenhouse gas reporting

Co-convenor

Unesco Chair in Global Environmental Change

United Nations Educational, Scientific and Cultural Organization

UNESCO Chair in Global environmental change

Mitigating climate change is one of the most important goals for strategic sustainable development. There is a clear and pressing need to quantify the greenhouse gas footprint of all human activities.

The greenhouse gas status of freshwater reservoirs – that is, any change in the greenhouse gas (GHG) emissions in a river basin resulting from the creation of a reservoir – has been the focus of a multi-year, multi-stakeholder research project led by IHA and the Unesco Chair for Global Environmental Change.

This session presented the results of the project and officially launched the G-res tool. A new conceptual framework was presented that reflects a net emissions approach, taking into account pre-impoundment conditions and naturally-occurring emissions.

G-res is an online tool that builds on this methodology and will enable users to estimate the GHG footprint of reservoirs, including hydropower reservoirs. The tool also takes into account emissions related to other human activities and infrastructure construction, and allocates emissions to various reservoir purposes.

Speakers

- **Vincent Chanudet,** Environmental Specialist, EDF
- **Jenny Choo,** Biologist, Sarawak Energy
- **Rikard Liden,** Senior Hydropower Specialist, Water Practice, World Bank Group
- **Yves Prairie,** Chair, Global Environmental Changes, Unesco
- **Mathis Rogner,** Senior Analyst, International Hydropower Association (IHA)
- **Richard Taylor,** CEO, International Hydropower Association (IHA; moderator)

The development of the G-res model, which is based on emissions data from over 230 global reservoirs, allowed the research team to investigate the various processes and factors that influence GHG emissions.


Yves Prairie


Rikard Liden


Jenny Choo

Researchers, tool developers and end users shared their insights on the development of the G-res tool, experiences of using the tool, and the tool's potential impact on future project development.

Key discussion points

Yves Prairie delivered an opening keynote presentation in which he introduced a new conceptual framework for the estimation and accounting of the net change in GHG emissions incurred during the formation of a reservoir. He noted that natural inland waters, such as lakes, rivers, and streams, are significant components of the carbon cycle.

Collectively, they emit approximately the same quantity of carbon dioxide as the oceans absorb in the average year. This highlights the significant potential impact of transforming a river into a reservoir. This is due to the transformation suppressing the carbon cycling of the terrestrial body and amplifying the processes occurring in the aquatic body.

Essentially, flooding a landscape changes the shape and land cover of the system, thereby exposing new sources of organic matter to the aquatic system and creating new areas which allow for methane formation. Additionally, the introduction of a reservoir to a river catchment system changes its hydrology.

Vincent Chanudet

Mr Prairie stressed that while these changes to the environmental system are significant, not all measured emissions should be attributed solely to the creation of the reservoir. The development of the G-res model, which is based on emissions data from over 230 global reservoirs, allowed the research team to investigate the various processes and factors that influence GHG emissions.

The G-res model accounts for the GHG balance of the reservoir before impoundment and takes into account the evolution of emissions as a reservoir ages. The model builds on foundational guidelines for estimating greenhouse gas emissions from land use change,

as set by the Intergovernmental Panel on Climate Change (IPCC) and refined by previous Unesco-IHP (International Hydrological Programme) and IHA work.

The research found that, on average, 75 per cent of carbon dioxide emissions from reservoirs can be considered natural. On the other hand, the majority of methane emissions can be attributed to reservoir impoundment.

However, there remains a large degree of uncertainty around the processes through which methane is released into the atmosphere, most notably through degassing.

By applying the G-res tool to a subset of the world's largest reservoirs by volume, the G-res study resulted in a global GHG footprint for reservoirs that is much lower that previously reported.

Mathis Rogner presented the preliminary results of the G-res tool when applied to reservoirs which serve hydropower purposes.

Approximately 500 hydropower reservoirs, with a global distribution across four climate zones, were tested using the G-res tool. The results revealed that the proxy relationship between power density and GHG emissions is serviceable, however he stressed that many of those reservoirs with low power densities offer significant water and energy services that are often not taken into account.

Preliminary results of the G-res tool for hydropower reservoirs highlighted the risk of multipurpose reservoirs that deliver essential water and energy services missing out on funding under the current Clean Development Mechanism methodology.

Water services include providing freshwater for municipal water supply, irrigation, managing floods and droughts, transportation fisheries, and recreation. Energy services include providing baseload power supply, although for reservoirs with low power densities, these power stations often provide peaking support, firming capacity and other essential ancillary power grid services.

By demonstrating the relationship between power density and emissions intensity (gCO_2eq/kWh) for this subset of hydropower reservoirs, Mr Rogner explained how the G-res tool can improve the assumptions used to formulate the United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism (CDM) eligibility rules.

The results showed that the majority of reservoirs between 4-10 W/m^2 were estimated to emit well below the assumed 90 gCO_2eq/kWh as stipulated in the CDM.

Richard Taylor, Yves Prairie

Most importantly, however, the results show that a large cluster of reservoirs below 4 W/m^2 were also well below the 90 gCO_2eq/kWh threshold. Mr Rogner stressed that these reservoirs, offering multiple valuable water and energy services, were at risk of not being funded.

Rikard Liden, Vincent Chanudet and Jenny Choo responded to the opening presentations. Liden stressed the importance of the tool to support decision making within the World Bank Group, explaining that it could support a new internal decision tree framework within the World Bank Group.

EDF and Sarawak Energy Berhad were both involved in the empirical studies used to develop and calibrate the G-res model. Mr Chanudet and Ms Choo emphasised the relative accuracy of the model for their measurements and highlighted the tool's value for choosing and designing suitable sites for hydropower development.


Mathis Rogner

What next?

The new conceptual approach around accurately accounting for GHG emissions from reservoir formation is the subject of an academic publication which will be published in late-2017. A revised assessment of the GHG footprint from freshwater reservoirs will follow shortly thereafter, as well as an investigation of hydropower's GHG footprint using the new methodology. This work will contribute to the 2019 refinement to the 2006 Guidelines for National GHG Inventories of the Intergovernmental Panel on Climate Change (IPCC).

The G-res tool will continue to evolve and be updated as the understanding of the processes that affect GHG emissions from reservoir formation improves. IHA, in cooperation with G-res partners and sponsors, is offering training both online and in person on using the tool. In addition, IHA also offers a consultancy service where G-res experts can perform assessments on existing or planned reservoirs for interested parties.

Try the G-res tool: hydropower.org/gres or hydropower.org/gres-tool

Hydropower and long-distance transmission

Co-convenors

Global Energy Interconnection Development and Cooperation Organization

New Partnership for Africa's Development (NEPAD)

Global Energy Interconnection Development and Cooperation Organization
全球能源互联网发展合作组织

NEPAD
TRANSFORMING AFRICA

Connecting the hydropower resource to major load centres can be challenging, particularly where the load centre is located a significant distance away from the generation source, nationally or internationally.

Long-distance transmission infrastructure can facilitate the delivery of generation to load centres, while also providing access to markets for the export of surplus electricity. This session explored some of the challenges associated with linking a country's hydropower capacity or available potential with domestic and international consumers and markets. For developing countries, connecting resources to major energy users has the potential to attract much-needed investment for the development or expansion of hydropower.

When properly planned, that investment can benefit the local population by providing vital access to energy, driving local economic development, and creating jobs.

During this session, experts and decision-makers discussed cases where large hydropower plants were developed and proved successful in terms of business performance and social benefits, as a result of support from long-distance infrastructure.

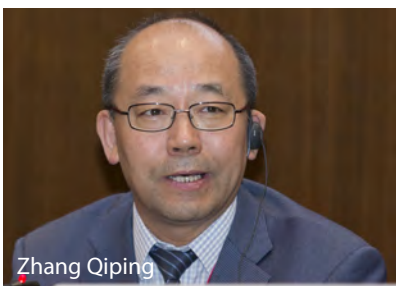
Speakers

- **Ralf Bucher,** Project Manager, Lahmeyer International
- **Mosad M. Elmissiry,** Senior Advisor to CEO, New Partnership for Africa's Development (NEPAD)
- **Jiang Longhua,** Vice President, China Electric Power Equipment & Technology Co.
- **Simon Mueller,** Head of Energy Integration, International Energy Agency (IEA)
- **Xiang Zejiang,** Vice President, China Huaneng Group
- **Zhang Qiping,** Chief Engineer, State Grid Corporation of China (SGCC)
- **Xie Kai,** Deputy General Manager, GEIDCO Research Institute (moderator)

Xiang Zejiang provided illustrative examples of the challenges China is facing in terms of interconnecting various regions. For example, east and west China are unbalanced in terms of resources and economy, while most hydropower projects are located in remote areas of west China, far away from load centres.

Xiang Zejiang

For developing countries, linking resources to major energy users will attract much-needed investment for the development or expansion of hydropower.


Zhang Qiping

Key discussion points

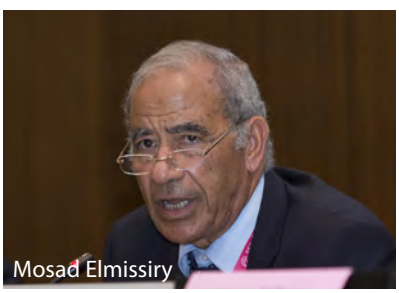
Zhang Qiping provided an overview of the current UHV (ultra-high voltage transmission lines) and the significant advantages of UHV over conventional HV.

He emphasised that UHV is unrivalled when it comes to developing large-scale energy bases and promoting the transformation from fossil fuels to clean energy systems.

Simon Mueller gave examples from several regions around the world of where long-distance interconnections are providing a range of benefits to achieve sustainable, secure electricity systems.

He pointed out that today there are over 50m kilometres of electricity grids in place – enough to cover the distance from the Earth to Mars. However, less than 1 per cent of these line lengths are currently dedicated to transmitting power across country borders.

Xiang Zejiang provided illustrative examples of the challenges China is facing in terms of interconnecting various regions. For example, east and west China are unbalanced in terms of resources and economy, while most hydropower projects are located in remote areas of west China, far away from load centres.


Mosad Elmissiry

He went on to discuss current technological solutions for optimising hydropower operations, better planning of transmission infrastructure and consideration of environmental issues.

Programme for Infrastructure Development in Africa (PIDA). The programme promotes regional economic integration by building mutually-beneficial infrastructure and strengthening the ability of countries


Jiang Longhua

to trade and establish regional value chains. PIDA has set the ambitious target of achieving 60 per cent energy accessibility in Africa by 2040.

Jiang Longhua presented further case studies of projects in Asia and Africa that illustrate the role UHV transmission is playing in providing access to hydropower. He emphasised that interconnections are key to eliminating energy poverty, and explained that it is imperative that the planning of electricity consumption and transmission is coordinated.

Ralf Bucher provided further examples of grid interconnection for regional development, presenting Lahmeyer's projects in Sudan and Ethiopia (Ethiopia-Kenya electricity highway).

Key outcomes

The panel discussion that followed the presentations focused on several sub-topics relating to grid interconnection to enable regional and economic development:

- Regional cooperation is needed to ensure that interconnected national grids function as one; to achieve this, operational frameworks (regulations/standards/software in load dispatch centres) need to be harmonised.
- Several European examples were discussed that show progress in coupling markets and connecting different spot markets, with short-term allocation of interconnection capacity.


Jiang Longhua, Mosad Elmissiry, Zhang Qiping

Simon Mueller

Simon Mueller gave examples from several regions around the world of where long-distance interconnections are providing a range of benefits to achieve sustainable, secure electricity systems.

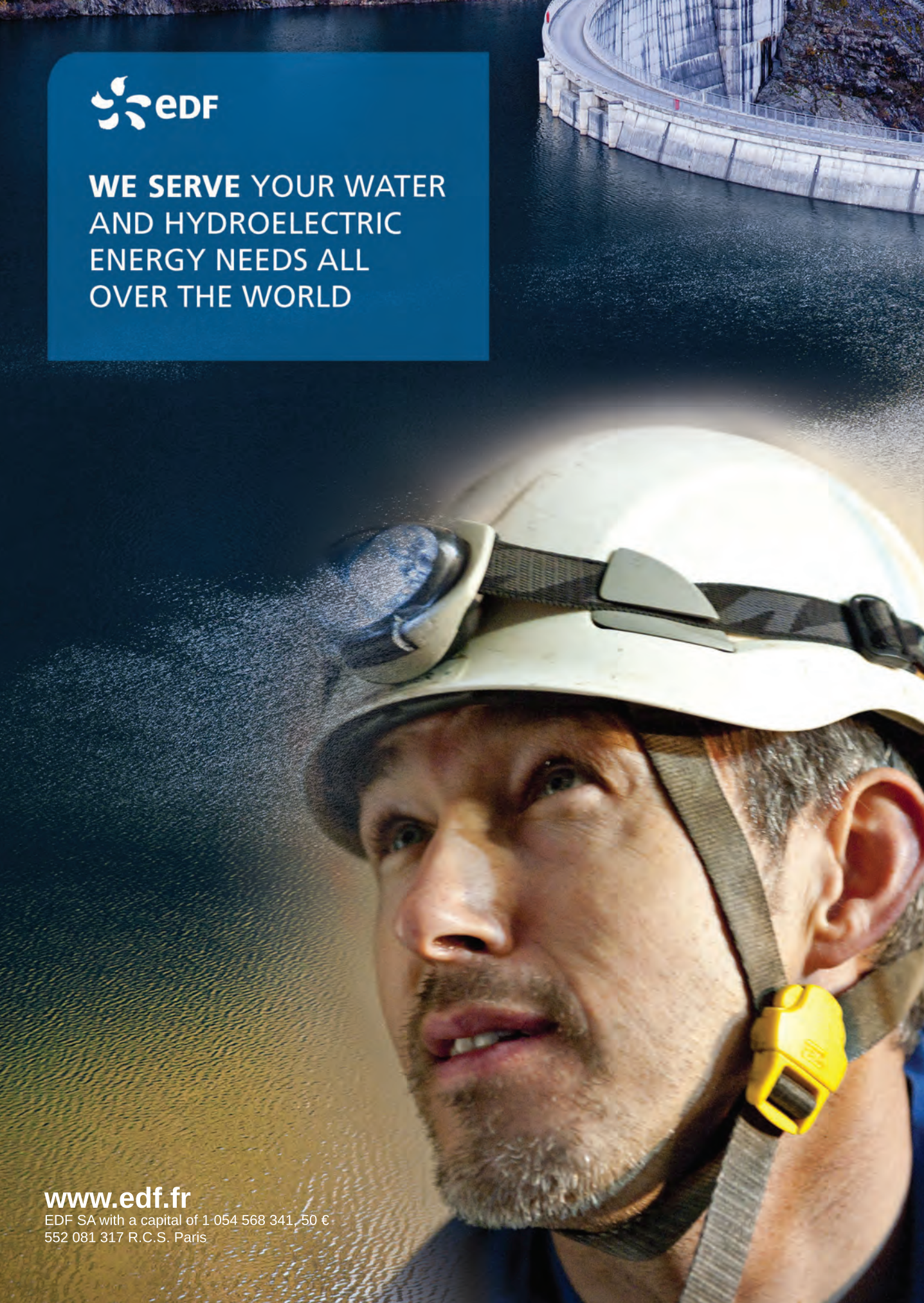
- The sharing of balancing and operation reserves requires a greater degree of alignment; there are challenges that could be avoided in countries with less mature systems by agreeing on interoperability at an early stage. Regional development requires political determination and leadership, and trust between countries to reap the full benefits of interconnections.
- It is essential that local communities and customers are able to see the benefits of regional interconnections; this is necessary to maintain commitment to building required infrastructure.

Ralf Bucher

What next?

Within its work programme, IHA plans to develop a set of recommendations for analysing transboundary project feasibility, with guidance on the role of hydropower in the development of regional power pools and bilateral interconnection agreements.

The recommendations will be proposed in the form of a white paper, which will be developed in cooperation with the knowledge network and expert group on regional interconnections, taking advantage of the expertise within IHA's broad network.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Strategic basin planning

Co-convenor
The Nature Conservancy

The Nature Conservancy
Protecting nature. Preserving life.™
nature.org

There is growing recognition that system-scale (or basin) planning is critical for successful hydropower development. This can help optimise not only energy systems, but also broader environmental, social, water and climate change outcomes.

A strategic river basin approach for site selection, with a comprehensive needs and options assessment, has demonstrated that a balance can be found between improved performance of environmental, social, economic and financial factors. Furthermore, basin-scale planning contributes to minimising cumulative and transboundary effects and planning mitigation measures more effectively.

This session addressed ways to optimise strategic planning at the basin level and demonstrate that basin-scale planning generates more economic gains, as well as environmental and social protections, compared to business as usual, project-by-project planning.

Participants discussed the financial and economic benefits and costs or difficulties as a result of basin-scale planning and presented their experiences of achieving a range of objectives from this kind of planning.

Speakers

- **David Harrison,** Senior Advisor, Global Water, The Nature Conservancy
- **Guo Xuyuan,** Chief Infrastructure Engineer, Yalong River Hydropower Development Co.
- **Maria Koenig,** GIZ Advisor to Mekong River Commission
- **Fekahmed Negash,** Executive Director, Eastern Nile Technical Regional Office
- **Jeff Opperman,** Global Freshwater Lead Scientist, World Wildlife Fund (WWF)
- **Óli Sveinsson,** Executive Vice President of R&D, Landsvirkjun
- **Jean-Michel Devernay,** Independent Expert (moderator)

David Harrison's presentation focused on 'The Power of Rivers: A Business Case', developed by The Nature Conservancy in partnership with McGill University, the University of Manchester and Physicians for Social Responsibility (PSR) - which proposes a 'Hydropower by Design' (HbD) approach through system-level planning.


David Harrison


Jeff Opperman


Maria Koenig


Óli Sveinsson

The session examined the added value of strategic basin planning, and looked at international case studies of successful initiatives, and the implications for hydropower.

David Harrison's presentation focused on 'The Power of Rivers: A Business Case', developed by The Nature Conservancy in partnership with McGill University, the University of Manchester and Physicians for Social Responsibility (PSR) - which proposes a 'Hydropower by Design' (HbD) approach through system-level planning. This concept entails a comprehensive and system-scale approach to hydropower planning and management that fully integrates other sectors from the earliest stages, with the aim of promoting sustainability and optimising the delivery of benefits.

The HbD approach was described as a way to not only improve social and environmental outcomes of hydropower projects, but also as a tool to reduce business risk and provide a broader set of water management benefits, such as irrigation, navigation, fisheries and water supply.

HbD was introduced as a framework to promote a more inclusive and integrated approach to selecting and developing projects among decision-makers, planners and investors. The approach includes mitigation, offsets and restoration. Thorough data collection and transparent stakeholder engagement are also key to the HbD approach.

An early-stage system-scale approach was deemed both feasible and implementable. Participants discussed how it could avoid poorly-sited projects that create conflict with values, environmental and social objectives and thus avoid costly delays, suspensions and possible cancellations.

The Power of Rivers report includes a review of case studies and also analyses examples such as the experience of implementing the HbD approach in the Magdalena basin in Colombia.

The panel discussion highlighted a number of issues. It was agreed that basin planning should be optimised to take into account existing and future planned projects. These could include other renewable energy sources, such as solar and wind, besides hydropower.

Jeff Opperman stressed that the 'right dam, built right' approach could increase

the performance of any project in the Hydropower Sustainability Assessment Protocol. Nonetheless, the project would also have to fit well in the basin system.

Óli Sveinsson emphasised that the cost of pre-project mitigation measures was very low compared to the total cost of the project, and could avoid the risk of costly delays.

Fekahmed Negash brought up the challenge of bringing stakeholders together at implementation level. Guo Xuyuan mentioned the case of China, where the government is responsible for basin planning.

There, hydropower development companies can only ask for development approval from the local government on sites that have been identified as feasible locations. It was agreed developers should systematically consult with affected people.

Following up on this, Maria Koenig highlighted the need to build trust between stakeholders. For example, in the case of the Mekong River Commission, there is a track record of long-term stakeholder engagement, including collaborations with organisations such as WWF and The Nature Conservancy.

However, Ms Koenig emphasised that river basin master plans should not consider only engineered solutions but also social and environmental aspects.


Jean-Michel Devernay

Key outcomes

System-level planning that addresses multiple purposes, and is carried out at an early stage of project development, can deliver broad economic benefits across a wide range of services.

This type of planning results in financially-sound projects, with improved risk management. It is both feasible and practical to implement such planning using existing tools, demonstrating that the approach does not have to be time-consuming or overly complex.

What next?

IHA's strategic priority for the topic of 'river basin planning' will be to develop a white paper or set of recommendations for sustainable and strategic development of hydropower projects, in particular those in transboundary basins.

The white paper or set of recommendations will be developed in cooperation with the relevant IHA knowledge networks and expert group, by researching and reporting on industry good practices on hydropower development at a river basin scale.

Future of project sustainability assessment

Co-convenor
Swiss Secretariat for Economic Affairs (SECO)

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Volkswirtschaftsdepartement EVD
Staatssekretariat für Wirtschaft SECO

The Hydropower Sustainability Assessment Protocol was launched at the World Hydropower Congress in 2011, and has since been applied across the globe.

The Hydropower Sustainability Assessment Protocol has been used to demonstrate compliance with international good practice, strengthen CSR functions and manage risk.

Over time, a wider range of applications, including capacity-building and self-assessment, have become available not only to developers and operators, but also to governments, financial institutions and donor organisations.

This session comprised an opening keynote presentation on the key trends in the application of the Protocol over the last few years, and the current challenges around its future uptake.

The panellists were then invited to present their own experiences of how the Protocol has been applied. They also considered how new derivative tools, currently under development, will expand the range of stakeholders adopting the Protocol as a guide to ensuring sustainable development.

Furthermore, the session explored the development of a bespoke environmental and social assessment tool based on established Protocol good practice, in addition to international industry good practice guidelines to foster improvement in the sector.

Speakers

- **Roger Gill**, Principal Consultant, Hydro Focus PTY, and Vice Chair, Hydropower Sustainability Assessment Protocol Governance Committee
- **Nick Wright**, Vice President, Business Development, Sarawak Energy Berhad
- **Mike Muller**, Professor, University of the Witwatersrand, South Africa
- **Kimberly Lyon**, Water Resources Management Analyst, World Bank Group
- **Romas Kamanga**, Senior Manager for Generation Support Services, ZESCO
- **Doug Smith,** Independent Consultant
- **Guy Bonvin**, Head of Infrastructure Financing Division, Department of Economic Cooperation and Development, SECO (chair)

With a relative decrease in volume of full Hydropower Sustainability Assessment Protocol assessments over the past few years, how can the Protocol remain relevant and reflective of market needs?

Nick Wright


Roger Gill


Mike Muller


Doug Smith

Key discussion points

The session opened with a keynote presentation delivered by Roger Gill, in which he presented the main challenge facing the future of the Hydropower Sustainability Assessment Protocol: with a relative decrease in volume of full assessments over the past few years, how can the Protocol remain relevant and reflective of market needs?

A panel discussion followed in which the panellists described their experiences and perspectives of using the Protocol.

Malaysian hydropower developer Sarawak Energy Berhad has applied the Protocol over five years, with a clear benefit in terms of the sustainability of their flagship Murum project.

In Nick Wright's view, the approach should be to target developers but to also make sure regulators understand the benefits of using the Protocol.

From a river basin perspective, Romas Kamanga, representing the Zambezi River Authority, pointed to the success of capacity-building support around protocol self-assessment in driving improvements in practice around stakeholder engagement within the basin.

Doug Smith, a Protocol accredited assessor, spoke of the need to reduce barriers to accessing the Protocol.

He described a recent trial of new Protocol derivative tools during an early-stage planning assessment in the Solomon Islands.

These tools include: a screening tool that will focus on environmental, social and governance aspects and that will establish good practice for a specific project; and industry good practice guidelines aimed at project developers, which will describe what is specific good practice for each Protocol topic.

The purpose of these tools is to broaden the range of uses of the Protocol and facilitate access, especially for smaller, lower-budget projects.

Kimberly Lyon from the World Bank Group explained the reasons behind the bank's support of the Protocol. These include developing capacity in client countries and the need to grow the number of feasible projects, bearing in mind only around 5 per cent of hydropower projects developed globally are currently funded by the bank.

Finally, Mike Muller offered a perspective from developing countries. In his view, the Protocol remains too heavily driven by the interests of major international donors and is perceived as an imposition on the governments of developing countries.

Key outcomes

Following its initial success in attracting developers to carry out full assessments, the Hydropower Sustainability Assessment Protocol must remain relevant to the evolving needs of the market. This is necessary in order for the Protocol to survive as a viable product.

Over recent years, interest from hydropower developers in full Protocol assessments has been decreasing. Instead, there has been more demand for capacity-building and training around the Protocol from international donors.

There is also a clear demand from international investors, such as the Climate Bonds Initiative, for a simplified screening tool that focuses on specific components of the Protocol.

At the same time, there is a common view that dissemination of the Protocol beyond the traditional Protocol community is necessary, with governments and regulators at the forefront of such outreach.

Guy Bonvin

Finally, the session underlined that, beyond its evolution, the Protocol's core pillars remain solid; the multi-stakeholder nature of its governance and the rigour of its scoring statements should not in any way be undermined.

The session moderator also appealed for more volunteers to join the chambers that make up the Hydropower Sustainability Assessment Council.

What next?

Building on the session and on the Protocol governance meetings held two days previously, the derivative tools (ie the Environmental, Social and Governance Tool and the Good International Industry Practice Guidelines) will be further developed.

This development will be overseen by the Protocol Governance Committee with support from multilateral donors, such as the World Bank Group and SECO.

In particular, it is hoped further work can be done to refine the environmental and social tool. This could include the inclusion of management plans to address significant gaps with established good practice. In addition, more example good practice guidelines covering different Protocol topics are foreseen.

The committee will look at the strategic direction of the protocol over the coming years, with a clear view to ensuring its financial sustainability in the long term.

Hydropower Sustainability Assessment Protocol: www.hydrosustainability.org

Hybrid renewable energy systems

Co-convenor
Global Energy Interconnection Development and Cooperation Organization (GEIDCO)

Global Energy Interconnection Development and Cooperation Organization
全球能源互联网发展合作组织

Hybrid energy systems typically consist of two or more different energy sources used in conjunction to ensure firm power output, increased system efficiency and ultimately a greater balance in power supply at lower overall costs.

Some hybrid systems use hydropower's flexibility to balance variable renewable supply, ensuring a firm power output to the grid and reducing spinning reserve requirements.

Other hybrid systems may include adding generation to existing systems, taking advantage of existing infrastructure and creating new revenue streams.

Innovative hybrid systems are wide-ranging and can solve numerous problems faced by modern energy systems. Cutting-edge control technologies can also enable hybrids by offering automatic digital responses to supply fluctuations for frequency control.

Hybrid systems can have extensive and significant related social, economic and environmental benefits beyond simply providing stronger and more efficient power systems.

Hybrid energy systems, along with renewable energy storage, may be key to the future of renewable energy.

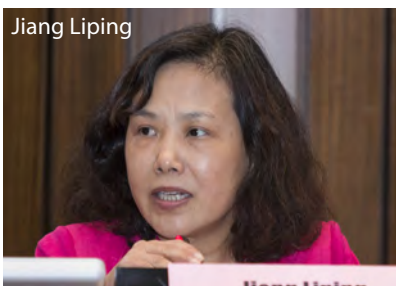
Speakers

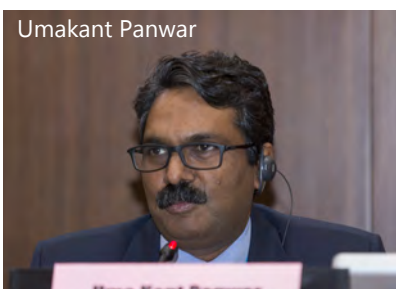
- **Wang Weisheng,** Director, New Energy Department of China
- **Miguel Patena,** Director, Equipment Engineering and Innovation, EDP
- **Yang Cunlong,** Vice President, Huanghe Hydropower Company
- **Umakant Panwar,** Principal Secretary, Department of Energy, Government of Uttarakhand
- **Jerry Ji,** President, EBG Energy Sector, Huawei
- **Jiang Liping,** Deputy President, China State Grid Research Institute (moderator)

Digitisation, including individual device sensors connected individual panels and turbines, will play a significant role in future systems.

Miguel Patena stressed that scaling up floating PV plants would decrease overall costs, but that this would require special regulation and licensing for hybrid plants.


Wang Weisheng


Jiang Liping


Umakant Panwar

This session explored recent technological innovations in hybrid renewable systems that include hydropower, by bringing together experts from research, business, government and industry.

Key discussion points

Wang Weisheng gave an overview of the current power generation system in China at the end of 2016, and outlined the distribution of renewable resources and exploitable capacity in the country.

He highlighted the regional heterogeneity of renewable resources and the long distances between renewable resources and demand centres.

As China is determined to increase the share of renewables in the energy mix, this will require integrated system planning across growing spatial and temporal scales. This is particularly important in order to maximise utilisation rates in power systems with high proportions of hydropower, wind and solar.

Giving both grid-connected and isolated grid examples, he stressed that high renewable contributions are achievable if available resource assessments, load demand, grid access and interconnections are all taken into account.

Miguel Patena presented a floating photovoltaic (PV) pilot project developed by EDP at the Alto Rabagao pumped storage reservoir in Portugal.

Mr Patena emphasised the complementarity of shared infrastructure, especially with respect to the transmission and distribution infrastructure. For example, there is greater efficiency due to water cooling from below, which results in less area being required to produce the same amount of power.

The transmission infrastructure also receives additional benefits. The floating PV uses the existing lines, and the transmission line efficiency is increased, as it is often used when the pumped storage is idle. On the other hand, hydropower generation loses its market margin when not generating, due to competing solar generation.

Miguel Patena, Yang Cunlong

Nevertheless, the capital investment for the floating PV is optimised and PV fluctuations in generation are smoothed.

As the EDP project has only been in operation since late-2016, no definitive conclusions can be drawn at this stage. Both the installation and operation of the project have gone smoothly so far.

Mr Patena stressed that scaling up floating PV plants would decrease overall costs, but that this would require special regulation and licensing for hybrid plants.

Additionally, virtual power plant managing systems would be needed to ensure efficient and optimal operation of both PV and hydropower.

Yang Cunlong presented the applications of hybrid systems in power grids that are already dominated by hydropower, using the Qinghai province in China as a case study.

Mr Yang noted that hydropower currently generates over 50 per cent of power for the province, which is closely followed by wind and solar power at 32 per cent. Qinghai is endowed with both high solar and hydropower resources, but a very small population. As the solar PV generation profile in the province does not meet the local demand curve, energy storage or hybrid operations are required.

Hybrid operations in this case regulate the output of solar PV to improve the safety, reliability and stability of dispatched


Miguel Patena


Umakant Panwar

Hybrid systems can have extensive and significant related social, economic and environmental benefits beyond simply providing stronger and more efficient power systems.

power, and are cheaper than investing in dedicated energy storage options.

A significant benefit of this example of hybridisation is the increased utilisation and efficiency of the existing transmission and distribution system.

Umakant Panwar offered an Indian perspective on the complementarity of PV and hydropower at a system scale. Citing his country's ambitious renewable energy goals, he explained the challenges it faces due to the variability, uncertainty and intermittency of renewables.

These challenges are accentuated when solar and wind receive dispatch priority, as they reduce the efficiency of flexible generators, especially thermal generators. He stressed that policy reforms are necessary in India to increase hydropower capacity due to its complementarity with solar PV generation.

Jerry Ji presented innovative ICT solutions to integrating renewable energy into power grids. Using smart inverters for solar PV, which are connected via wireless internet to large data centres and centralised operations and maintenance (O&M) centres, can result in higher yields, reduced O&M costs and higher internal rates of return. Adding this smart ICT technology to the 'internet of things' can help

Jerry Ji

to strengthen the transformation of traditional power grids into digitised, renewable-dominated systems.

Key outcomes

The hybridisation of variable renewables with hydropower can allow for smooth, stable and reliable output to power grids. More importantly, however, co-location allows for the optimised use of existing transmission and distribution infrastructure.

Advanced control systems will be required to optimise the operation of the renewable energy system. Digitisation, including individual device sensors connected to individual panels and turbines, will play a significant role in future systems.

What next?

IHA, in collaboration with international experts and IHA's knowledge network on this topic, will produce a series of case studies on hybrid renewable energy systems at all scales, from bundled co-located projects to national and regional systems.

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Salini Impregilo is a leading global player in the construction of major complex infrastructures. It specializes in the water sector, where it is recognized by the Engineering News-Record (ENR) as the global leader for the 4th consecutive year, as well as railways and metro systems, bridges, roads and motorways, large civil and industrial buildings, and airports The Group has 110 years of applied engineering experience on five continents, with design, engineering and construction operations in 50 countries and more than 35,000 employees from 100 nationalities. Salini Impregilo is a signatory of the United Nations Global Compact and pursues sustainable development objectives to create value for its stakeholders. It assists clients in strategic areas including energy and mobility, helping to drive development and well-being for current and future generations. Its leadership in the hydropower sector is reflected by projects such as Gibe III, Koysha and the Grand Ethiopian Renaissance Dam in Ethiopia.

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Renewable energy storage

Co-convenor
International Energy Agency (IEA)

It is widely recognised that the transition towards cleaner and more sustainable energy systems will require a significant increase in the flexibility of power systems.

Flexibility in the context of a power system refers to its ability to maintain a reliable and continuous service when faced with potentially rapid changes in supply or demand.

Electricity storage can help with providing this flexibility and reducing the costs of system operation by shifting excess supply to periods of peak demand.

This flexibility means that electricity storage can offer a broad variety of advantages and benefits to system owners, grid operators, electricity producers and consumers.

This importance will only grow as variable renewable energies increase their share in power grids.

The increasing share of variable renewables, such as wind and solar, inherently reduces the flexibility of a power system.

By their very nature, a high penetration of variable renewables makes the supply side more dynamic and fluctuations more severe, while also displacingexistingflexibletechnologies.

This session explored the changing landscape for energy storage technologies, including storage

Speakers

- **Sakari Oksanen,** Deputy Director General, IRENA
- **Yves Rannou,** President and CEO, GE Renewable Energy
- **Lin Mingshan,** Chairman of the Board, State Grid Xinyuan Company Ltd.
- **Norbert Riedel,** Chief Technical Officer, Voith Hydro
- **Qian Ganglian,** Deputy Chief Engineer, China Renewable Energy Engineering Institute
- **Jiang Xiaobing,** Senior Engineering and Technical Specialist, China Gezhouba Group Corporation
- **Simon Müller,** Head of Systems Integration of Renewables, International Energy Agency (IEA; moderator)

The panel agreed that pumped storage systems are not competitors to other energy storage technologies, but that each technology can complement the others in contributing to the energy transformation.

reservoirs, pumped storage and other emerging and innovative technologies. It also looked at the policy and market mechanisms that can ensure stable power grids and cost-effective energy storage operations.

Key discussion points

This session focused on the importance of energy storage as an essential means of enabling increased penetration of variable renewables into future energy systems.

The panel agreed that pumped storage systems are not competitors to other energy storage technologies, but that each technology can complement the others in contributing to the energy transformation.

While other options such as demand-side management, transmission interconnections and supply flexibility exist, pumped storage development in the recent past had been neglected.

Appetite for pumped storage is, however, increasing worldwide, especially in China. In its 13th five-year plan, China is looking to optimise the regional distribution of pumped storage and accelerate its development. This includes plans to commission 17 GW by 2020, while a further 60 GW of pumped storage will begin construction in that time.

Panellists mentioned new innovations in pumped storage technology and operation. The coupling of variable speed pumped storage with long-distance high-voltage direct current (HVDC) transmission lines would allow for large amounts of variable renewable energy to be transported to demand centres.

The pumped storage plants in such a system would enable a more efficient use of transmission lines and would allow for the evacuation of variable renewable energy power. The panel agreed, however, that significant changes needed to occur in order to see pumped storage and other energy storage technologies thrive. This requires that manufacturers have a comprehensive

understanding of the entire value chain surrounding pumped storage.

To unleash the potential of pumped storage hydropower, the panel agreed on four key enablers:

- The value and purpose of pumped storage needs to be clearly explained to stakeholders and decision-makers.
- Permitting needs to be simplified on the back of changing regulatory frameworks.
- Cost reductions need to be maintained.
- Energy markets need to be redesigned as there is a lack of a balancing market with suitable price signals.

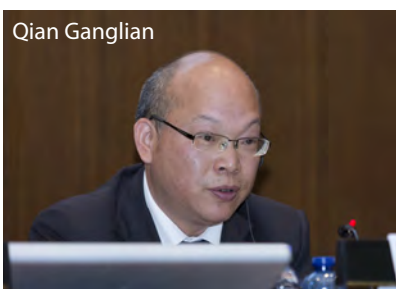
Sakari Oksanen

Key outcomes

While the importance of energy storage is clear to industry professionals, its value in terms of decarbonising energy systems needs to be better communicated to stakeholders and decision-makers. This requires a fundamental redesign of licensing, regulations and market mechanisms.

Further discussions emphasised that effective communication around pumped storage could improve public perception and understanding of the technology. Joining this, though, a panellist observed that in effect, pumped storage was the 'only green battery on earth'.


Jiang Xiaobing


Qian Ganglian

What next?

IHA will continue its work in communicating the role of hydropower in the energy transition. IHA will build upon the key outcomes of the session by publishing a series of briefings dedicated to sharing and building knowledge around the role of pumped storage in future clean energy systems. Working with the support of international experts and contributions from IHA's knowledge network and members, the briefings will focus on:

- the current status of pumped hydropower storage;
- innovations in technology and operations;
- the role of pumped storage in enabling and integrating variable renewables into modern energy systems;
- the role of pumped storage in increasing the system value of power grids;
- how pumped storage and other energy storage technologies can complement eachother;
- an exploration and summary of the market reform options that will enable increased adoption of energy storage technologies.

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Private sector engagement

Co-convenor
Inter-American Investment Corporation (IIC)

Inter-American Investment Corporation
A Member of the IDB Group

The private sector plays a key role in hydropower development, both in providing the necessary technical skills but also as a source of financing.

There a number of different financing models and instruments available that involve the private sector. The appropriate financing structure will vary according to site and country-specific circumstances.

Barriers to investment can often include the lack of a strong regulatory framework and the complexities involved, particularly for large-scale projects.

Over the past 10 years, power purchase agreements have proven to be an increasingly popular mechanism.

This is especially the case in emerging markets, where they have helped to address power shortages.

Like other models, including public-private partnerships, creating a common understanding between parties is essential in order to best allocate and mitigate risk and achieve a balanced, durable and bankable agreement.

In this session, power producers, government advisers and experts identified the key challenges and opportunities. They also explored how governments and international financial institutions can leverage greater private sector participation.

Speakers

- **Carolyn Blacklock,** Specialist Adviser, Papua New Guinea Government
- **Li Yinsheng,** CEO, China Three Gorges (CTG) Brazil, and Executive Vice President, CTG International
- **Gil Maranhão Neto,** Chief Strategy, Communications and CSR Officer, Engie Brasil
- **Mike McWilliams,** Head of Hydropower, Mott MacDonald
- **Gabriel Azevedo,** Head of Environment, Social and Governance, Inter-American Investment Corporation (IIC; moderator)

Citing Brazil as an example of a country that has successfully utilised its hydropower resources, Gil Maranhão Neto stressed the importance of a well-developed regulatory regime with respect to attracting private sector development.

Gil Maranhão Neto

A key takeaway from the session was that there is no single model, instrument or financing arrangement which works best across the sector.

In addition, panellists discussed the replicability of successful experiences from around the world, and helped lay out what constitutes industry best practice.

Key discussion points

Offering a public sector perspective, Carolyn Blacklock spoke of the challenges faced by developing economies such as Papua New Guinea (PNG) in attracting experienced private sector companies to develop their hydropower resources.

Only 12 to 15 per cent of PNG's population have access to electricity (the country's total installed capacity is 580 MW). However, the country's hydropower potential is in excess of 15,000 MW.

Ms Blacklock said the government currently lacks the capacity to attract and deal with private sector players and inadequate governance has deterred investment in key infrastructure projects in the past.

Li Yinsheng outlined the challenges the private sector faces when investing in hydropower projects. In particular, he noted that some projects can take 30 years to recover the initial investment, making hydropower a unique industry in terms of return on investment.

He went on to describe the three most important elements needed for successful projects. Firstly, a quality location characterised by favourable hydrological conditions. Secondly, strong demand with stable economic growth. And thirdly, an enabling regulatory framework (political and policy stability).

Citing Brazil as an example of a country that has successfully utilised its hydropower resources, Gil Maranhão Neto stressed the importance of a well-developed regulatory regime with respect to attracting private sector development.

Over the past two decades, the Brazilian power industry has undergone a dramatic transformation, including the deregulation and implementation of renewable energy auctions.

While not without their own challenges, the reforms have helped propel the country towards becoming a global leader in renewable energy.

Mike McWilliams briefly covered the various project financing models employed by the hydropower sector. These include Build, Own, Operate (BOT) and Build, Own, Operate, Transfer (BOOT).

He explained how a model proposed by Mott MacDonald, known as FELT (Finance, Engineer, Lease and Transfer), could better apportion risk and control of a project.

Under the FELT model, a government-owned entity carries out the preparation studies, obtains the relevant licences and then procures a developer once it is 'shovel ready'.

The developer then constructs the project ('engineers') and, upon completion, hands it back in return for defined annual payments over a period of time ('lease'), at the end of which complete ownership sits with the government entity ('transfer').

Similar to the aims of the Hydropower Preparation Support Facility, the FELT model looks to significantly reduce the front-end (preparation phase) risks to the private sector developer.

Li Yinsheng

Key outcomes

A key takeaway from the session was that there is no single model, instrument or financing arrangement which works best across the sector. Private hydropower development in many countries is still in a state of evolution, following decades of power market deregulation.

Hydropower financing is very much a site, state and country-specific proposition. Increasingly, we are seeing different models and sources of finance used in conjunction with others in an attempt to best reduce and allocate the risk associated with hydropower development.

What next?

Building on this session's key outcomes, IHA is undertaking a number of initiatives aimed at increasing private sector participation in the development of sustainable hydropower.

The proposed Hydropower Preparation Support Facility is one such example which is seeking to reduce the high risk associated with complex early-stage project preparation for private developers. Other initiatives include the development of industry-accepted criteria, which enables developers to access the growing green bond market and a methodology to identify, quantify and communicate the multiple benefits of hydropower to decision-makers and other stakeholders.

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Benefits of hydropower

Co-convenor
United Nations Economic Commission for Africa (UNECA)

Single and multipurpose hydropower facilities have the potential to make substantial contributions at the local, regional and national level.

In addition to export revenues, they provide other local macroeconomic benefits relating to employment, education, and recreation, and open up new possibilities for trade, transport and tourism.

Hydropower facilities can also provide services such as flood mitigation, water supply, pollution control and irrigation.

To realise the full value of hydropower projects and improve the risk-reward profile for developers and investors, properly identifying and quantifying these benefits is of critical importance.

The benefits of hydropower developments are often under-reported, and companies and project developers struggle to collect, quantify and share information on these benefits. This is due to the lack of an adequate framework or template that enables them to communicate these added values to society and ensure it is possible to take advantage of these opportunities.

At this session, panellists shared their experiences of the multiple benefits created by hydropower development, from a local, national and regional perspective. They discussed the need to accurately identify and quantify these benefits to support the decision-making process.

Speakers

- **Ragna Árnadóttir**, Deputy CEO, Landsvirkjun
- **Antoine Badinier**, Deputy Vice President, EDF
- **Soteri Gatera**, Chief, Industrialisation and Infrastructure Section, UNECA
- **Katai Kachasa**, CEO, Lufubu Power
- **Nick Wright**, Vice President, Business Development, Sarawak Energy Berhad
- **Jacob Irving**, President, Canadian Hydropower Association (moderator)

"Hydropower is the energy of choice of Africa." - **Soteri Gatera**, Chief, Industrialisation and Infrastrure Section, UNECA


Soteri Gatera

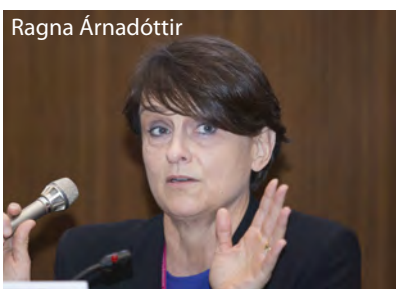
Systems and guidelines need to be developed to improve the ways benefits can be identified, quantified and effectively communicated to decision-makers.


Jacob Irving

Key discussion points

This session provided examples of the multiple benefits derived from hydropower development from the perspectives of both developed (France and Iceland) and developing countries (Malaysia and Zambia). An overarching theme was the importance of stakeholder engagement at the earliest opportunity.

EDF has been a sector leader in seeking to identify and evaluate the benefits created by hydropower projects. Antoine Badinier presented the company's 'Value Creation Assessment Methodology'. He described how the methodology has been applied to projects in France and Canada, but noted that the challenge for the sector is to come up with better ways in which to accurately quantify the non-power benefits of hydropower. This is particularly the case in the planning stages of a project.


Ragna Árnadóttir

Badinier's intervention prompted discussions on how best to quantify the sector's contributions to wider value chains and food and water security within and across national boundaries.

The keynote address was delivered by Soteri Gatera from UNECA, who noted that: "Hydropower is the energy of choice of Africa." He placed much emphasis on the need to develop a comprehensive methodology to quantify the non-power-related and macroeconomic benefits of hydropower projects.

Mr Gatera ended his address by setting the goal of "ECA teaming up with IHA to develop a tool that demonstrates the comprehensive benefits of hydropower schemes aimed at investors and policy-makers".


Antoine Badinier

Key outcomes

While hydropower has significantly contributed to the economic development and industrialisation of many countries, systems and guidelines need to be developed to improve the ways benefits can be identified, quantified and effectively communicated to decision-makers. This is particularly true for hydropower's non-power benefits, which can be difficult to monetise. An initiative in this direction would not only better inform the public of the importance of hydropower, but would also support decision-making in the planning stages of a hydropower project's development.

What next?

IHA will continue to work in partnership with UNECA and, together with experts in the field, will develop a methodology and reporting tools to best identify, evaluate and effectively communicate the multiple benefits of hydropower development.

The intention is for the methodology to be used on both planned and existing projects.

As part of this project, briefing documents and a user's manual will be developed and a webinar organised to demonstrate how the methodology would work in practice, with feedback sought from a wide variety of stakeholders.

The completion of the methodlogy is expected by the end of 2018 and a case study of it being used in the field will be presented at the 2019 World Hydropower Congress.

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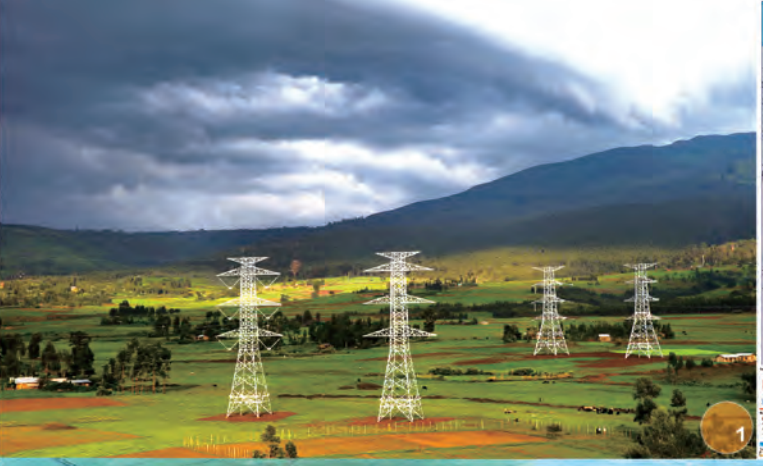

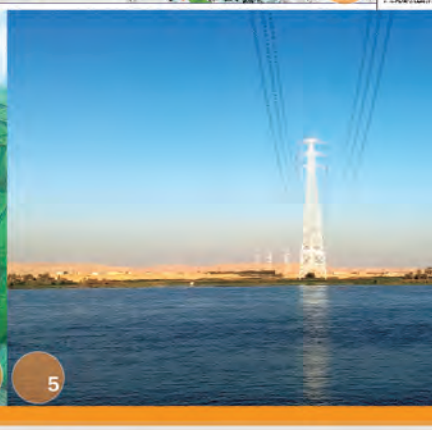

Project Achievements

1. Ethiopian GDHA 500 kV Power Transmission and Transformation Project

Ethiopian State Grid Backbone Network Project; Build two 500 kV substations and expand three 400 kV substations, 1,250 km 500 kV double circuit line and 98 km 400 kV double circuitline, with total transmission capacity of 6,000 MW. The project was completed and delivered inDecember, 2015.

2. Ethiopia – Kenya ±500 kV DC Power Transmission Project

The transmission capacity is 2,000 MW, and the total length of the line is 1,054 km. CET is responsible for 450 km transmission line in the territory of Ethiopia. It was the first HVDC transmission line in East Africa. The construction was started in August, 2016.

3. Belo Monte II ±800 kV UHV DC Transmission Project

2,518 km transmission distance; build ±800 kV Xingu and ±800 kV Rio converter stations and supporting projects at the two ends; build two 30 km 500 kV transmission lines. It will be started construction in 2017.

4. Matiari-Lahore km 660kV DC transmission Project in Pakistan

Build 878 km of 660 kV DC transmission line and two converter stations at both ends; rated current: 3,030A, transmission capacity: 4,000 MW. Licensed operation period: 25 years. Construction will start in 2017.

5. Transmission Project for Upgrading of Egyptian EETC 500 kV Backbone Network

As the first successfully signed China-Egypt cooperative capacity project, it comprises a 1,210 km commontower double-circuit 500 kV AC line. The project was commenced in January 2016. Phase I line construction was completed in November 2016.

Small-scale energy systems

Co-convenor
United Nations Industrial Development Organization (UNIDO)

Small-scale hydropower can play an important role in providing energy access to remote areas in developing countries. It has also proven successful in other contexts.

The short lead time for developing and constructing these types of facilities can be an incentive for smaller-scale systems.

Connecting remote generating facilities to isolated mini-grids can bring electricity to communities where connection to a central grid is economically unfeasible.

However, when evaluating potential sites, it is important that an overall energy plan and watershed management scheme has been implemented. This approach is essential for ensuring that small-scale hydropower development is done sustainably, with appropriate consideration of environmental and social issues.

This session explored the rationale, benefits and challenges associated with small-scale energy systems.

It addressed the role small-scale energy systems can play in meeting a country's energy needs in the context of an increasing global need for green energy. Participants also discussed the best basin-wide planning practices to deliver the greatest benefits.

Speakers

- **Alexandros Korkovelos,** PhD Researcher, Swedish Royal Institute of Technology
- **Frédéric Louis,** Hydropower Coordination Director, EDF International Division
- **Sister Yoela Luambano,** Director, Tulila Project, African Benedictine Sisters of St Agnes
- **Ghislain Nicolas,** Small Hydro Leader, GE Renewable Energy
- **Rana Singh,** Industrial Development Officer, United Nations Industrial Development Organization (UNIDO)
- **Anton-Louis Olivier,** CEO, Renewable Energy Holdings (REH) Group (moderator)

Sister Yoela Luambano presented the unique experience of a community of Benedictine nuns from Tanzania, who developed, built and now operate the 5 MW Tulila hydropower plant, with funding from a Swiss donor. The project benefits from a high USD 0.26/kWh feed-in tariff with the Tanzanian state energy company, TANESCO.

Yoela Luambano

There is growing recognition that site selection and evaluation of the most suitable project size is critical for successful hydropower development.


Rana Singh

Key discussion points

Anton-Louis Olivier pointed out the importance of developing small hydropower plants, particularly in countries where the electricity system is underdeveloped. He suggested that small-scale systems are most likely to be implemented by local and regional independent power producers (IPPs).

Rana Singh noted that high energy cost has a negative impact on a country's industrial development, and therefore on its overall economic growth.

He cited the example of smaller-scale hydropower in China, which represents an installed capacity equivalent to the sum of the country's four largest hydropower plants, demonstrating that smaller power plants can make an important contribution.

Mr Singh explained that smaller schemes have the advantage of providing energy on the spot with the least energy lost in transmission. As such, small-scale schemes have the potential to engage remote rural populations in their own economic activity.


Anton-Louis Olivier

Frédéric Louis presented EDF's approach for the development of smaller-scale hydropower projects. He pointed out the interest in developing project portfolios, rather than isolated projects, starting with the simplest projects with the lowest risks.

He also pointed out that schemes with small reservoirs can be coupled with photovoltaics (PV), connected to the plant switchyard. This would allow 24-hour supply to remote communities and small industries.

Ghislain Nicolas presented GE's experience with Kaplan's low-head turbines and pointed to the danger of over-specification. He also mentioned the interest in digitisation, which facilitates smart intervention on the machinery.


Ghislain Nicolas

Mr Nicolas commented that small-scale hydropower makes an important contribution to sustainability, having become more flexible and with a wider operating range. It is therefore better suited to areas where the grid capacity or connection is weak.

Small-scale hydropower can also help to reduce the cost of energy with proper involvement from technology companies to ensure a safer and more reliable investment.

Sister Yoela Luambano presented the unique experience of a community of Benedictine nuns from Tanzania, who developed, built and now operate the 5 MW Tulila hydropower plant, with funding from a Swiss donor. The project benefits from a high USD 0.26/kWh feed-in tariff with the Tanzanian state energy company, TANESCO. The nuns were trained to operate the plant themselves.

Alexandros Korkovelos, 2017 IHA Young Researcher of the Year, presented his initial findings on the technical assessment of small-scale hydropower (0.01-10 MW) in Sub-Saharan Africa using open-source geospatial datasets.


Frédéric Louis


Alexandros Korkovelos

The discussion highlighted that it is important that the international community be able to overcome the limited the view of classifying hydropower into 'big' and 'small' or 'good' and 'bad'.

Key outcomes

Smaller-scale hydropower developments are usually run-of-river projects. Due to their versatility, low investment costs and relatively low impact on the environment at a project level, they play an important role in producing sustainable, inexpensive energy.

Such plants are particularly important in rural or developing areas, where small-scale hydropower can represent a locally-available, reliable source of energy where larger generation is not feasible. Standardised projects can significantly decrease investment costs and make smaller-scale systems more readily available.

There is growing recognition that site selection and evaluation of the most suitable project size is critical for successful hydropower development.

There is a need for more integrated basin-level planning, in order to optimise not only energy systems, but also broader environmental, social, water and climate change outcomes.

A tendency to promote and subsidise smaller-scale hydropower up to specific capacity limit, rather than considering the most appropriate option for the site, can lead to poor decision-making and wasted potential.

The discussion highlighted that it is important that the international community be able to overcome the limited the view of classifying hydropower into 'big' and 'small' or 'good' and 'bad'. Instead, participants were invited to look at hydropower as a whole, selecting the best option for the specific site during the planning stage, and building it in the most sustainable way.

It is clear that smaller-scale systems have an important potential to fulfil, and that this technology is likely to become increasingly popular due to a growing need for energy in the developing world.

The Tulila hydropower project is an excellent example how rural electrification through small-scale systems can make a real difference. It is important to pay attention to smaller-scale energy systems and isolated grids, which can often be overshadowed by larger energy system issues.

What next?

Small-scale systems will be analysed from several angles in the upcoming two-year work programme of IHA: sustainability performance, clean energy systems, as well as finance and investment.

A number of IHA members are already involved in the development of small hydropower systems and IHA will continue to connect members and partners, including governments, who are interested in collaborating on this topic.

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Capacity-building and skills shortages

Co-convenor

Association of Power Utilities of Africa (APUA)

Hydropower development and operations require a variety of expertise. With greater involvement from new players in the sector, increased expectations for plant reliability and longevity, and added emphasis on international standards, knowledge gaps have widened.

To bridge these gaps, build expertise and share good practices, IHA brings together stakeholders and facilitates knowledge networks to respond to challenges facing the hydropower community worldwide.

This session featured an interdisciplinary panel of stakeholders and centred around expanding support to capacity-building activities at international, national and local levels. Panellists also addressed the need to further strengthen educational institutes to produce a highly-skilled workforce in the hydropower sector.

The discussions also covered the importance of management, operations, monitoring, technical services, operating costs, evaluating and planning throughout the value chain in the hydropower sector, as well as policy and regulatory frameworks and applicability in each country in order to extend the impact of improved capacity-building in the hydropower sector.

Speakers

- **Gabriel Azevedo**, Head of Environment, Social and Governance Division, Inter-American Investment Corporation (IIC)
- **Heike Bergmann**, Senior Vice President, Sales Africa, Voith Hydro
- **Harrison E. Mutikanga**, Chief Executive Officer, Uganda Electricity Generation Company Limited
- **Kaela Kennedy Siame**, Director, Kafue Gorge Regional Training Centre
- **Abel Didier Tella,** Director General, Assocation of Power Utilities of Africa (APUA)
- **Eugenio Zoppis**, Gibe III Project Manager, Salini Impregilo

Professional capacity-building and work experience programmes in large world-class companies would deliver long-term benefits.


Abel Didier Tella


Heike Bergmann


Eugenio Zoppis

Panellists addressed challenges facing the fields of capacity-building and skills shortages, and identified solutions to ensure the improved performance of new and existing hydropower assets around the world.

Key discussion points

The background to the discussion was the establishment of the African Network of Centers of Excellence in Electricity (ANCEE), a pan-African initiative led by APUA and supported by the African Development Fund of the African Development Bank Group and the Agence Française de Développement (French international development agency, or AFD).

The overall objective of the project is to improve the performance of the electricity sector and intensify regional trade by strengthening the technical and managerial skills in different areas, as well as strengthening the governance of the sector. By 2019 the network will consist of at least eight training centres bearing the label of excellence of the ANCEE. It was noted that the Kafue Gorge Regional Training Centre is already part of it.

The panellists presented their experiences of building capacity and addressing skills shortages within the hydropower industry, predominantly with reference to Africa. Developers, construction companies and equipment suppliers have set up programmes to


Kaela Kennedy Siame

train local workforces. It was, however, agreed that further capacity-building within the hydropower industry could generate positive outcomes.

For basic and mid-level skilled workers, capacity-building could deliver more jobs, better distribution of income during project implementation, increase community knowledge around the local hydropower project and promote community ownership of the project. It is clear that professional capacity-building and work experience programmes in large world-class companies would deliver long-term benefits, or a legacy for the local community.

There was also much discussion on the involvement and value of including more young people in hydropower projects, including further collaboration

with local universities. Language barriers were identified as a key challenge for capacity-building when it comes to training employees.

Key outcomes

There is still a distinct lack of skilled local employees, especially in developing countries/rural areas. More could be done to engage with local universities and employ skilled local workforces for hydropower projects, for example through sustainable internship placements or graduate programmes. Such initiatives would promote more engagement and mobilisation from local communities.

Further collaboration and funding is required to support more training centres like the Kafue Gorge Regional Training Centre. In Africa, language barriers remain a key obstacle in the context of training local employees. Large international companies often depend on translators and consultants. It may be more beneficial for all parties if local employees lead the training sessions so that they can be executed in the local language/dialect if required.


Gabriel Azevedo

More could be done to engage with local universities and employ skilled local workforces for hydropower projects, for example through sustainable internship placements or graduate programmes.

What next?

Through its knowledge networks, IHA contributes to the building and sharing of knowledge within the hydropower sector. Briefings and guidance to developers and operators on issues such as climate resilience, sustainability, communications and asset management are part of the upcoming 2017-2019 work programme.

The World Hydropower Congress was an opportunity to improve exchanges with young people, who were invited to contribute through the African Union Youth Programme. Further exchanges will take place to create stronger relations with academia and young professionals ahead of the 2019 World Hydropower Congress.

Climate resilience

Co-convenor
UNECA - African Climate Policy Centre (ACPC)

Many countries are seeking to gain a better understanding of the impacts of climate change - both positive and negative - and are beginning to build strategies and approaches to incorporate climate resilience into their plans.

A likely next step for partners working in this field is to develop sector guidelines both for climate change adaptation services and for the incorporation of climate resilience into existing hydropower facilities currently at risk, new facilities, and modernisation projects.

To address this risk, the World Bank Group has launched an initiative, supported by IHA, which aims to produce a practical set of climate resilience guidelines. These would be designed to ensure that both existing and future hydropower projects are resilient to climate change.

This session was an opportunity to hear about good practices from key global players. It also introduced the proposed guidelines for building climate resilience into both planned and existing hydropower projects.

Representatives from developed and developing countries presented their own experiences of the central role climate resilience plays in hydropower development within their jurisdictions.

Speakers

- **Denis Aelbrecht,** Chairman, ICOLD Technical Committee on Climate Change
- **Peter Baum,** Senior Manager, European Bank for Regional Development (EBRD)
- **Alain Bourque,** Executive Director, Ouranos
- **Linus Mofor,** Senior Expert, African Climate Policy Centre (ACPC)
- **Bill Girling,** Senior Hydropower Sector Analyst, International Hydropower Association (IHA)
- **Pravin Karki,** Senior Hydropower Specialist, World Bank Group (moderator)

Linus Mofor spoke of harnessing the 'resilience dividend' for long-lived infrastructure investments in Africa.


Linus Mofor

For climate resilience to be institutionalised globally, leaders in the sector will need to step up and offer their experience and guidance to support less developed countries.


Denis Aelbrecht

Key discussion points

Linus Mofor spoke of harnessing the 'resilience dividend' for long-lived infrastructure investments in Africa. He introduced the African Climate Resilient Investment Facility (AFRI-RES), an Africa-based network of technical competence and excellence. The facility's overall objective is to build the capacity of African institutions and the private sector (project developers and financiers) to plan, design and implement infrastructure investments that are resilient to climate variability and change in selected sectors.

Bill Girling reiterated the importance of having clear and concise guidelines for building climate resilience into existing and future hydropower projects. He then presented some of the key outcomes from the climate resilience workshop held immediately prior to the congress.

Denis Aelbrecht summarised the main outcomes of the ICOLD technical bulletin, published in early 2017. The bulletin addresses climate change issues for dams, reservoirs and water resources, from a risk/opportunity management perspective.

Bill Girling

Peter Baum presented case studies from projects in the EBRD's area of interest that demonstrate experience in building climate resilience at project level.

Alain Bourque described the work Ouranos has done in the field of climate resilience. Hydro-Quebec supported the creation of the Ouranos Consortium, and has attracted other utilities, telling success stories of companies improving their climate resilience.

Investing in science to build resilience is seen as an opportunity to achieve a better cost/benefit ratio in the long term, rather than placing a burden on a project or organisation.

Key outcomes

Discussions within the panel and the question and answer session highlighted several key messages around the need for climate resilience in the field of hydropower. These included:

- The cost of building in climate resilience should not be seen as an incremental to the base costs for hydropower development. This is, in most cases, not appropriate; current thinking around climate resilience would treat this as a base cost for ensuring hydropower projects are safe, reliable and will operate under expected climatic conditions.
- For climate resilience to be institutionalised globally, leaders in the sector (Hydro-Quebec, EDF and others) will need to step up and offer their experience and guidance to support less-developed countries in building acceptance and capacity to use the guidelines effectively.

Peter Baum

The cost of building in climate resilience should not be seen as an incremental to the base costs for hydropower development, which in most cases is not appropriate.

What next?

The final report on climate resilience guidelines, prepared by a consultancy, is expected to be released by the end of summer 2017, following a stakeholder meeting in Washington DC in July. Thereafter, World Bank Group and IHA will coordinate a consultative workshop with key representatives of the hydropower sector (industry representatives, financial institutions) to disseminate the key outcomes of the study report and prepare the draft version of the guidelines by the first half of 2018. Once finalised, IHA will publish a briefing note on the climate resilience guidelines.

NARI 南瑞集团公司
NARI GROUP CORPORATION


Kariba Dam

Africa's hydropower development initiates relatively late and encounters twists and turns all the time, with the installed capacity accounting to less than 2% of the global until 1960s, when the most of the African countries have declared independency. Recently, though power industry has been promoted by its economic growth, hydropower development is still very slow, with the installed capacity climbed up to only 3% of the global. In fact water resources is very abundant in Africa, Congo River, Zambezi River, the Nile River are all feasible for construction of large-sized hydropower plants. In terms of hydropower construction, China is crowned as the most experienced country. Responding to the Belt and Road Initiative, NARI dedicates itself in the development of Africa's hydropower industry, adding bricks for the course of African economic promotion and poverty alleviation.

NARI Hydropower Resources and Hydropower Company has already conducted nearly 30 projects, including Zambia Kariba North and Sourth Bank, Ethiopia FAN, Ethiopia Jibe Ⅲ and other HPPs in Ethiopia, Zambia, Kenya, Ghana, Cameroon, etc. Its supply scope contains Supervisory & Control, Speed Governor, Excitation, Protection, Dam Safety Monitoring, Hydrological Telemetry and Reservoir Dispatch, Small Hydropower Integrated Automation, Condition-based Monitoring and Small Hydropower Integrated Automation System.

The 220km-long, 40km-wide Kariba Lake, covering 5580km^2, is the largest artificial lake in the world. NARI supplies Supervisory & Control System as the control core for Kariba North Bank Expansion Project, adding the capacity up to 4×180MW, shouldering 54% of national load, bringing lights to thousands of Zambian households, exporting electricity to the neighboring countries like South Africa, Namibia and Zimbabwe.

Group Photo of the Training Session

NARI is also committed to Africa's hydropower development and technical training through the International Network on Small Hydropower and Common Market for Eastern and Southern Africa- COMESA. In 2012, authorized by Chinese Ministry of Science and Technology, NARI undertook the 15-day's Training Program on Water Conservancy & Hydropower Automation and Environmental Protection Technology for Developing Countries, providing training sessions for government officials or technicians from Ethiopia, Kenya, Zambia, etc. In June, 2016, the capital city of Kenya, NARI's expert gave lectures for the Small Hydropower Training Program hosted by the International Network on Small Hydropower, in which representatives from 7 African countries like Ethiopia, Kenya, Rwanda, Madagascar, Mawlawi, etc. participated.


President of Zambia visited Kariba North Bank HPP

Climate bonds for hydropower

Co-convenor
Climate Bonds Initiative (CBI)

Climate bonds and green bonds are examples of the emerging instruments for green finance and investment in the energy sector that could be used for hydropower.

Climate bonds and green bonds are fixed-income loans created to specifically finance and refinance projects and assets that help address environmentaland/orclimaterisks,and that shift investment to a low carbon, sustainable economy.

Over USD 80bn of labelled green bonds were issued in 2016, nearly doubling the value of the previous year; yet the market is still in its early stages of development.

Last year, the Climate Bonds Initiative, an investor-focused, not-for-profit organisation, launched a Hydropower Technical Working Group (TWG). The group was tasked with developing criteria for climate-compatible hydropower investment.

Taking a robust, science-based approach, the group is developing simple and transparent criteria to identifythosehydropowerinvestments and assets that deliver climate mitigation, incorporate measures to address resilience and adaptation impacts and adhere to environmental and social good practice.

Speakers

- **James Dalton,** Coordinator of Water Initiatives, International Union for the Conservation of Nature (IUCN)
- **Pedro Luiz de Oliveira Jatobá,** Superintendent of Foreign Operations, Eletrobras
- **Pravin Karki,** Senior Hydropower Specialist, World Bank Group
- **Kelly Malone,** Partner, King & Spalding
- **Richard Taylor,** CEO, International Hydropower Association (IHA)
- **Anna Creed,** Head of Standards, Climate Bonds Initiative (moderator)

Richard Taylor noted that the green bonds market offers the hydropower sector greater choice with respect to financing.

Richard Taylor

The panel shared their experiences and provided commentary on the development of the criteria, and what they could mean for the future of hydropower development and financing.

IHA joined representatives from industry, the finance sector and international NGOs to discuss the objectives, scope and emerging outcomes of the working group, and what it will mean for the future of hydropower financing.

Key discussion points

Anna Creed opened the session with an overview of the green bonds market, its growth to date, and the development of criteria for the hydropower sector.

The panel shared their experiences and provided commentary on the development of the criteria, and what they could mean for the future of hydropower development and financing.

Richard Taylor noted that the green bonds market offers the hydropower sector greater choice with respect to financing. However, they currently only represent 1 in 1,000 bond issuances, so the market is still very much in its infancy.

He noted that the criteria developed by the TWG needs to be realistic and achievable to ensure the market is used by the sector.

Kelly Malone outlined some of the current structural limitations of the green bonds market for hydropower. These include: the exclusion of large hydropower from a number of issuances (affecting projects larger than 20 MW); that such funding is likely only to be appropriate once a project has greatly de-risked (ie entered its construction or operation phase); and that historically green bonds haven't been price competitive compared to vanilla bond issuances (higher yield), although this is changing.

Pravin Karki explained the World Bank Group's involvement in the market: 127 issuances, raising USD 9.6bn to date. He also introduced the climate resilience guidelines the bank is helping to develop for the sector, which will inform the work being undertaken by the TWG.

Other issues raised during the session included: how the market could help lower the risk of existing systems by

financing climate adaptation and resilience measures (James Dalton); how the criteria would deal with pumped storage systems (Richard Taylor); the role and development of the green bond market in Brazil (Pedro Luiz de Oliveira Jatobá); and new tools to measure net greenhouse gas emissions of hydropower projects.

Key outcomes

Much emphasis was placed on the need for the CBI's criteria to strike the right balance between setting internationally ambitious standards and those that will be achievable by the sector. This is especially important in the case of developing countries, so they are not excluded from tapping into this growing market.


Kelly Malone

Anna Creed

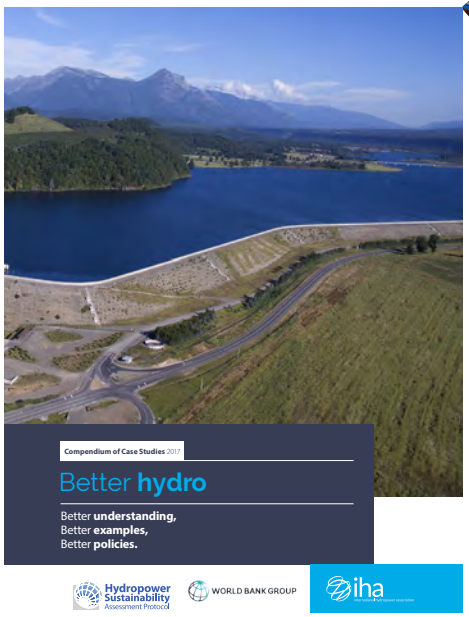
Pedro Luiz de Oliveira Jatobá

What next?

IHA will continue to be heavily involved in the CBI's Technical Working Group (TWG) as it develops the draft criteria, which are scheduled to be published before the end of 2017. A key task of the group is the development of screening tools to be used to identify eligible hydropower assets.

Once the draft criteria are published, they will be open for public consultation and industry will be involved to ensure they are fit for purpose and the tools are practical and cost-effective. The criteria will then be assessed by the Climate Bonds Standards Board for approval with the aim of them being available for use by the market from next year.

Finally, IHA will undertake further work exploring how, and at what stage of a project's development the green bond market will be utilised by the sector to identify and share key trends.



Better hydro
Case studies
available for download

Approaches to sediment management

Co-convenor
Water and Land Resource Centre - Addis Ababa University (WLRC-AAU)

Water & Land Resource Centre
Addis Ababa University

Hydropower energy production is being reduced by loss of reservoir storage capacity as a result of sedimentation. This is occurring at an annual rate of 1 per cent globally.

Extreme rainfall and erosion due to climate change will continue to increase the rate of sedimentation. Sedimentation is not only responsible for the loss of storage capacity but also causes environmental problems.

Sediment management seeks to maintain the sustainability of reservoirs, extending benefits such as energy and water supply and flood protection in the long term.

Nature-Based Infrastructures (NBI) offer considerable potential to reduce erosion rates in the watershed, and in turn reduce sedimentation in reservoirs. Prevention via NBI can even alleviate the need for other high-cost interventions in sediment routing and removal strategies. As such, the economic and financial returns of NBI should be considered in sediment management. NBI can also offer additional benefits to those associated with multipurpose reservoirs, such as flood protection, water supply, livelihood provisions and, in particular, can reduce the risk of natural disaster. It creates opportunities to develop an integrated watershed approach when planning and operating a dam.

This session focused on the mitigation options for reservoir sedimentation,

Speakers

- **Waqar Khan**, CEO, Star Hydro
- **Jian-hua Meng**, Water Security Lead, WWF International
- **Greg Morris**, Consultant, GLM Engineering COOP
- **Rafael Schmitt**, IHA Young Researcher of the Year 2017
- **Gete Zeleke**, Director, Water and Land Resource Centre - Addis Ababa University
- **Roger Gill**, Consultant, Hydro Focus Pty Ltd (moderator)

A website on sediment management and a collection of case studies are currently being developed by IHA with support from the World Bank Group, which was presented at a workshop prior to the congress.

Greg Morris

given that sustainable hydropower is set to play a prominent role in countering the effects of climate change.

The session addressed the various sediment management strategies, from mitigation to sediment routing and removal, and looked at the consequences of inappropriate sediment management downstream.

Following further research to reverse the net storage loss, and therefore improve the sustainability of hydropower, the World Bank Group published 'Extending the life of reservoirs: sustainable sediment management for dams and run-of-river hydropower'. Subsequently, the bank launched a new initiative to collect and identify criteria based on case studies to assist in pre-feasibility level decision-making on sediment management.

A website on sediment management and a collection of case studies are currently being developed by IHA with support from the World Bank Group. This was presented at the workshop on sediment management prior to the congress.

This focus session explored how sediment management is addressed at the international, national and local levels and how companies approach the issue. Are there new approaches to sediment management from research, governmental and non-governmental institutions? Are there partnerships between companies and others institutions to address sediment management? Are there financial mechanisms for sediment management?

Key discussion points

Gete Zeleke's opening address focused on sediment management upstream. He described the problem of dams in Ethiopia and Eritrea filling up with sediment over very short time periods. In contrast, he presented options intended to solve, or at least minimise, the problem through measures such as watershed management.

Revegetation of upstream areas makes land more productive, which in turn can bring economic benefits for the local community. Loess Plateau in China is a good example of successful watershed management.

In Ethiopia, in the Grand Ethiopian Renaissance dam (GERD) basin, the WLRC-AAU has identified some hotspots in which to apply the 'Learning Watersheds' pilot project successfully.

According to the results of the model, reducing the soil deposits into GERD by 25 per cent would increase hydropower revenue by USD 140bn, while reducing deposits by 50 per cent would result in an increase in revenue of USD 246bn.

Mr Zeleke also explored the obstacles to the wider implementation of watershed management. He remarked that there is not yet enough scientific methodology, and that sediment management is generally not accounted for in the overall cost of hydropower projects.

Waqar Khan focused on the sediment management problems operators face, and the strategies that can be put in place at sites. Sedimentation affects the

longevity of hydropower assets, and generation can be severely impacted and reduced.

In terms of the technical aspects, models have been developed to improve the design of, for example, runners and turbines, depending on the sediment particles.

To prolong the life of equipment exposed to water, hard-coating has proven the most durable solution.

As a developer, Mr Khan's main concerns relate to the following areas of sediment management strategies: commercial aspects; regulatory requirements; ecological impacts (future environmental regulations in Pakistan that dictate that sediment strategies will not affect the downstream habitat); bed load to impact in backwaters; and financial aspects (strategies that are high in cost but pay off in the long term).

Rafael Schmitt presented his PhD research, which combines sediment management with fluvial morphology and system basin scale planning.

He used a model called 'CASCADE' to minimise the trade-off between sediment trapping and hydropower generation through strategic portfolio optimisation. His model is, however, very computationally demanding. Site-by-site design is however very unlikely to deliver an optimal portfolio or minimise the trade-off between sediment trapping and hydropower generation.

Jian-hua Meng highlighted the downstream impacts of sediment trapping. The river transports bed load as well as suspended load (nutrients, bacteria, life support system), necessary for all of the livelihoods and ecosystems along the river.

The negative impacts are multiple: river starvation can affect the infrastructure; alteration to flow velocity and fluvial dynamics can cause loss of habitats, delta retreat and therefore increase salt intrusion, and so on.

Sediment routing is a win-win strategy. However, maintaining sediment connectivity in a river becomes more complex when there is a cascade hydropower scheme.

To minimise or avoid impacts downstream, it is essential to use strategic basin planning in order to select the right site and dam, with the most appropriate sediment management strategy.

Finally, Greg Morris, summarised the other panellists' key points. The first step is to tackle watershed issues, based on local experience, especially for large reservoirs. This is the most cost-effective strategy, and a win-win solution.

Secondly, there are technical strategies, such as tunnel bypass or desanders, that should be incorporated in a project's original design. The design of intakes is crucial, as is turbine and technical equipment coating.

Thirdly, small developers may not necessarily have a long-term vision, and may choose a site with less sediment yield from the government's screening of sites.

Gete Zeleke

It is essential to use strategic basin planning to select the right site and the dam, with the most appropriate sediment management strategy.

Finally, sediment trapping can have some positive impacts in reducing erosion downstream. However, the bed load can also cause river starvation over hundreds of kilometres, with long-term impacts.

Key outcomes

Watershed management upstream needs to be considered during the planning phase of a new hydropower project, and should be included in the project's total cost. For sustainable watershed management, it is necessary to take into account existing land-use systems and local knowledge.

Operators aim to extend the longevity of their assets. Hard-coating of equipment has proven an excellent protection for hard fine particles. It is also important to incorporate the infrastructure needed for sediment management in the original project design - for example, if desanders are not necessary but a tunnel bypass is - as is ensuring optimal intake design.

There are growing concerns about environmental regulations for sediment routing and removal strategies.

Modelling at the basin scale can optimise a hydropower portfolio by minimising the trade-offs between sediment trapping and hydropower generation. However, this incurs significant computational times.


Jian-hua Meng

Bed load trapping causes river starvation in the long term, and can extend for hundreds of kilometres downstream. Suspended sediment load can be routed more easily.

What next?

IHA is currently coordinating the project 'Analysis of the Impact of Sedimentation on Dams and Reservoirs: Case Studies', funded by the World Bank Group. This study will contribute to identifying and documenting case studies that demonstrate a variety of sediment management practices across different geographies and methodologies.

The project aims to disseminate knowledge on how sustainable sediment management is beneficial for the hydropower sector.

IHA will continue to be heavily focused on documenting sediment management practices with the support of the members. A report summarising best practices in sediment management will be published.

IHA will create guidance to report on sedimentation risks by working in cooperation with the relevant IHA knowledge network and expert group.

While this workstream is focused mainly on disseminating sediment management strategies, further work could be undertaken to explore linkages with topics such as operation and maintenance or climate resilience.

In addition, the Hydropower Sustainability Assessment Protocol will incorporate a 'how-to' guide on erosion and sedimentation next year.

Social aspects

Co-convenor
Hydropower Sustainability Assessment Protocol

Social aspects can be challenging to overcome if developers are not able to gain the support of affected communities and obtain a 'social licence'.

Projects involving physical and economic displacement and indigenous peoples can be more challenging to manage, and complex social issues can jeopardise, delay or halt hydropower development.

In all cases, engaging with all affected stakeholders from the project inception, and awareness of how to implement good practices, are key elements of sustainable hydropower development.

This session provided an update on the work led by the management entity of the Hydropower Sustainability Assessment Protocol on hydropower social aspects.

The session presented the areas to which the hydropower sector needs to pay more attention, according to the results of Protocol assessments.

Panellists introduced tools developed to assist developers in overcoming social challenges and achieve basic good practices. The session presented the perspectives of hydropower developers, NGOs, and social experts.

Speakers

- **Aida Khalil,** Senior Sustainability Specialist, International Hydropower Association (IHA)
- **Fabien Nathan,** CSR Officer, EDF Hydro-engineering Centre
- **Michael Simon,** Co-director of Programs, International Rivers
- **Doug Smith,** Independent Consultant
- **Eduard Wojczinski,** Principal, EW Sustainable Hydropower Consulting

Fabien Nathan presented a case study on the implementation of a tailored livelihood restoration plan, which is designed to address sand miners affected by the Nachtegal hydropower project in Cameroon.


Fabien Nathan

To help improve performance, IHA welcomes case studies that demonstrate good practice in projects that have affected indigenous peoples.

Key discussion points

Aida Khalil highlighted that assessees had performed more poorly on the topics of resettlement and indigenous communities than on other social topics.

Ms Khalil explained that, as the management entity of the Hydropower Sustainability Assessment Protocol Council, IHA is developing a number of tools to improve the sector's performance on these topics. These tools include how-to guides on resettlement and indigenous peoples, Good International Industry Practice Guidelines, and an Environmental, Social and Governance Tool.

Eduard Wojczinski, lead author of the how-to guide on indigenous peoples, presented its format and contents. The guide is primarily aimed at project planners, developers, owners and operators who have limited or no experience of engaging with indigenous peoples. The guide is designed to walk these users through the processes and deliverables required by the indigenous peoples Protocol topic, with a special focus on engagement and consultations. It will also include a set of case studies.

Doug Smith, lead author of the Good International Industry Practice Guidelines and the draft Environmental, Social and Governance Tool, introduced the publications and presented an example of a topic template on 'communications and consultation'.

The aim of the guidelines is to fill a gap in the good practice material available to the hydropower sector. The previous sustainability guidelines, drawn up in 2004, have now been superseded by the Protocol.

The new guidelines are based both on the protocol and on practical experience in assessments, and would take the form of a short document.

The draft environmental and social assessment tool is being developed in response to a specific request from the Climate Bonds Initiative Technical Working Group.

The request called for a screening tool that focuses specifically on established good practice in the environmental and social topics of the Protocol.

The tool covers 10 environmental and social Protocol topics, closely aligned with the standards of international financial

institutions such as the World Bank Group, and maintains the assessment rigour of official Protocol assessments.

Fabien Nathan presented a case study on the implementation of a tailored livelihood restoration plan, which is designed to address sand miners affected by the Nachtegal hydropower project in Cameroon.

The plan followed International Finance Corporation (IFC) performance standards and focused not only on compensation for those affected by the construction of the scheme, but also on longer-term retraining and linkages to economic development. Livelihood restoration is one of the most challenging social aspects for the sector.

Michael Simon singled out the Nam Lik project in Lao PDR as exemplary from a social point of view, with a very clear and consistent commitment to working with local people in an ongoing process.

In order to identify areas where more work is needed, it is important to effectively analyse those projects that have not scored as well. This would enable better understanding of the context behind the low scores and would allow for tailored improvement plans to address any underlying issues. Mr Simon appealed for a greater focus within the social aspects field on human rights and diversity.

Respondents at the session supported the development of new Protocol tools, and emphasised the added value these can provide to projects.


Aida Khalil

Key outcomes

According to Protocol assessments, the performance of the hydropower sector is poor on certain social topics, in particular on resettlement and indigenous peoples.

Aspects that require more attention include early, meaningful and continuous stakeholder engagement, livelihood restoration and improvement of living standards. In the case of indigenous groups, net benefits should be identified where possible.

To help improve performance, IHA welcomes case studies that demonstrate good practice in projects that have affected indigenous peoples.

All participants emphasised that the Protocol can be used to help hydropower projects to identify and manage social issues. The Protocol and new tools derived from it can prompt developers to carry out early consultations with stakeholders and better manage the necessary issues with affected communities.

The Protocol and the new tools being developed will complement existing regulations and policies. These tools can then be adopted internally by developers and operators.

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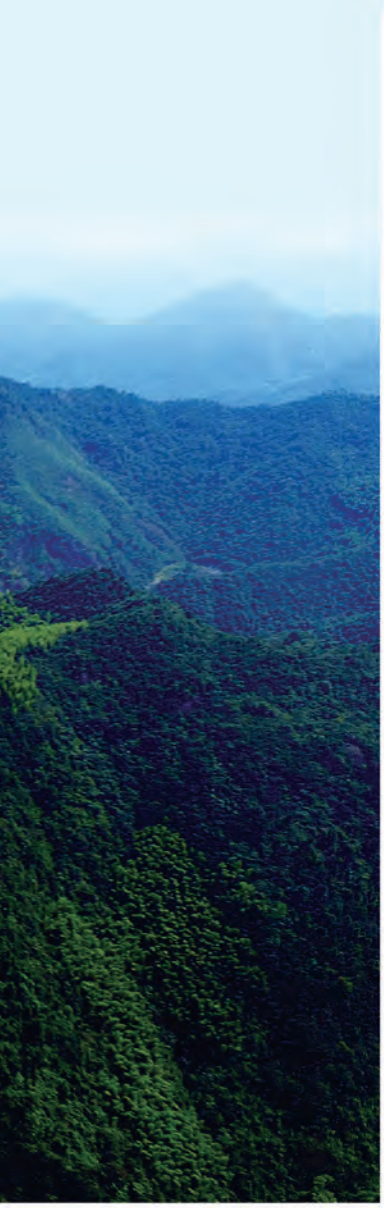
State Grid Xinyuan Co. Ltd. (hereinafter referred to as SG Xinyuan) was founded in Mar. 2005, with a registered capital of RMB10.286 billion. Currently, State Grid Corporation of China(hereinafter referred to as SGCC) has 70% of shareholding, and China Three Gorges Corporation has 30%. SG Xinyuan is mainly responsible for development, construction and management of pumped storage power plants and conventional hydro power plants. It undertakes the basic mission to serve for clean energy development, extra-high voltage smart grid construction, as well as safe stable and economical grid operation. SG Xinyuan is the world largest company specialized in peak regulation and frequency control power supply.

Since its foundation, SG Xinyuan has been developing the enterprise spirit as “in search of excellence, in pursuit of outperformance”. SG Xinyuan implements group operations, intensified development, lean management and specialized construction. It has realized the sustainable development of growing speed,safety quality, efficiency and benefit. By the end of Mar. 2017, SG Xinyuan has a total assets of RMB 77 billion, and has 55 subsidiary companies. With a total staff members of 6226 distributed in 20 provinces (autonomous regions and municipalites), and a total installed capacity of 45800 MW, SG Xinyuan has carried out the feasibity study and pre-feasibility study projects over 50000 MW.



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As the backbone of promoting clean energy development and global energy interconnection construction, pumped storage power plants are meeting important development oppotunities. SG Xinyuan is devoted to promoting the sustainable and safety development of pumped storage industry. SG Xinyuan will be in accodance with SGCC strategic deployment, promoting high standard values and innovations,and will be committed to build an enterpise with digital intellegent plants and information smart enterprise. By the year 2020, the controllable installed capacity under SG Xinyuan will be 75000MW (29000MW under operation, 46000MW under construction), significantly increased the ability of management, core competitiveness, grid serving and industry leading. SG Xinyuan is striving to make world first class level pumped storage power plants management enterprise and hydropower demonstration enterprise, making contributions to the clean, low carbonized, safe and sunstainable development of energy.

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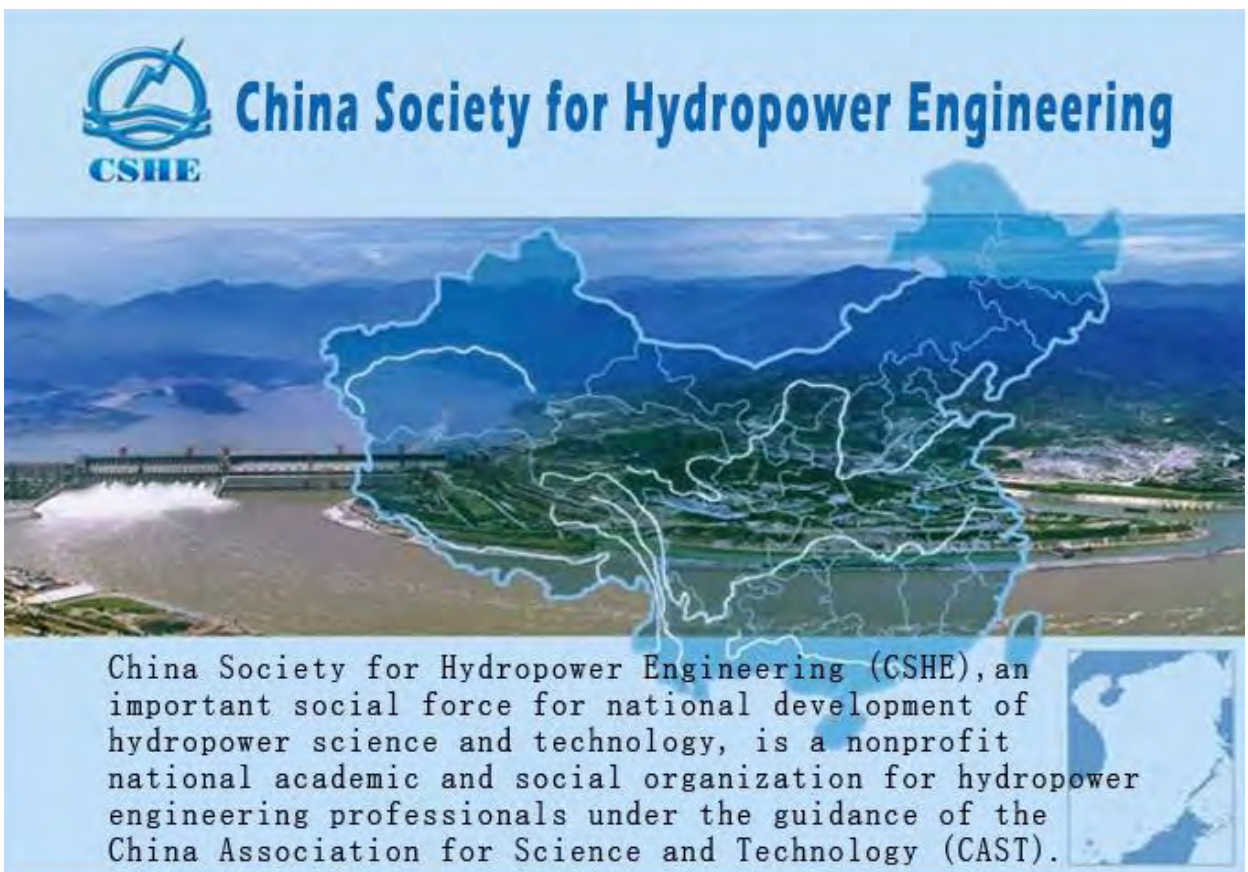

CSHE
China Society for Hydropower Engineering
China Society for Hydropower Engineering (CSHE), an important social force for national development of hydropower science and technology, is a nonprofit national academic and social organization for hydropower engineering professionals under the guidance of the China Association for Science and Technology (CAST).

Inga development

The Grand Inga project, located in the Democratic Republic of Congo (DRC), has the potential to transform Africa's power sector.

Co-convenor

Agency for the Development and Promotion of Grand Inga - DRC

The project will be built in a series of stages and, when fully completed, could be the largest power station in the world, with a potential installed capacity of 45 GW.

The next stage of the project, Inga 3, is set to begin construction in the coming years.

During this informal lunchtime session, Bruno Kapandji, Head of the Office for the Development and Promotion of the Grand Inga Project, provided updates on the project's planning, financing and the potential benefits it could deliver for the African power grid.

Key discussion points

Bruno Kapandji stressed the potential importance of the Grand Inga project for transforming the African power sector. He explained that Inga could act as a catalyst for the development of transmission lines and interconnectors to link the various sub-Saharan power pools.

The project will be developed through a series of six stages, each of which would be economically profitable. It will start with Inga 3, which, including the Basse Chute, would have a total installed capacity

Speakers

- **Bruno Kapandji,** Minister, Agency for the Development and Promotion of Grand Inga - DRC (ADPI-DRC)

Bruno Kapandji stressed the potential importance of the Grand Inga project for transforming the African power sector. He explained that Inga could act as a catalyst for the development of transmission lines and interconnectors to link the various sub-Saharan power pools.


Bruno Kapandji

of 7,800 MW when completed.

The five other stages are: Inga 4 (7,182 MW), Inga 5 (6,970 MW), Inga 6 (6,684 MW), Inga 7 (6,707 MW) and Inga 8 (6,747 MW).

The Grand Inga project could supply power to a number of African countries. Kapandji noted that a treaty had already been signed with South Africa to export the 2,500 MW produced by the Inga 3 Basse Chute (low head) phase via electric lines built throughout southern Africa, including Zambia, Zimbabwe and Botswana. It was also reported that Nigeria and Egypt have also expressed interest in importing power from Inga.

Much of the power produced from the Inga 3 project will be used for export and to supply the domestic mining industry in the Katanga region of DRC. The income generated from power exports would then be used to finance other development activities in DRC, as well as to improve the operation and maintenance of existing hydropower assets in the country. It would also be invested in expanding local transmission and distribution networks.

ADPI made a call for more financing and pointed to the African Development Bank (AfDB) and African Union Commission (AUC) for support, and called on NGOs and other international institutions present.

Mr Kapandji pointed out that Inga would not only benefit Africa's citizens, but also international businesses hoping to invest in the continent.

It was announced that the tendering process for Inga 3 has begun, and that offers have been received from three major companies, one each from China, Spain and Canada. The official decision has not yet been disclosed, but is likely to happen around July 2017.

Key outcomes

Following discussions with the audience, the following points were clarified:

- The Inga 3 project will go ahead, and lack of support from the World Bank Group is not perceived to be an obstacle for the DRC.
- The results of the Inga 3 tendering process will be announced in 2017, and construction could begin as soon as early 2018.
- The Inga project is marketed as a pan-African project for the benefit of the continent and not just DRC.

What next?

In June 2017, ADPI announced its decision to request the two remaining consortia (ProInga and Chinese) to produce a single optimised offer for the development of Inga 3.

Embedding sustainability practices

Co-convenor
World Bank Group

WORLD BANK GROUP

One of the key developments of the Hydropower Sustainability Assessment Protocol has been a model of guided self-assessments, where accredited assessors work with internal teams who assess their own projects.

This informal lunchtime session was an opportunity to share practical experiences of using the Protocol, particularly in this context.

The self-assessment approach is primarily aimed at those clients interested in gaining hands-on training in using the Protocol and developing internal action plans for improving project performance.

This session brought together practitioners from a range of projects around the world to describe how they have successfully used the Protocol as a guided self-assessment tool.

The session featured a series of presentations from the Zambezi River basin, Vietnam and Indonesia. This was followed by a panel discussion, where the views of Protocol accredited assessors were represented.

Speakers

- **Christopher Chisense,** Director, Water Resources and Environmental Management, Zambezi River Authority (ZRA)
- **Joerg Hartmann,** Independent Contractor
- **Romas Kamanga,** Senior Manager, Generation Support Services, ZESCO
- **Aida Khalil,** Senior Sustainability Specialist, International Hydropower Association (IHA)
- **Aida Majbaia,** Laboratory and Environment Deputy Manager, Hidroeléctrica de Cahora Bassa
- **Le Thi Ngoc Quynh,** Deputy Director of Science, Technology and Environment Department, Vietnam Electricity
- **Abdul Malik Sadat Idris,** Deputy Director of the Institutional Infrastructure of Water Resources, Indonesian Ministry of National Development Planning (BAPPENAS)
- **Kimberly Lyon,** Water Resources Management Analyst, World Bank Group (moderator)

The Matenggeng pumped storage project and nearby multipurpose reservoir projects in central Java, Indonesia, have used the results of the Protocol to assess risk in resettlement plans, flood control, cultural heritage and indigenous peoples.

In Vietnam, training has been given to 15 EVN assessors for the internal self-assessment of two projects in the operation stage.

Abdul Malik Sadat Idris

Key outcomes

Speakers described how guided self-assessments using the Protocol have led to discernible benefits in the sustainability performance of their hydropower projects.

In the case of the Batoka Gorge hydroelectric scheme on the Zambezi River, between Zambia and Zimbabwe, local Zambezi River Authority (ZRA) internal assessors were trained to carry out on-site interviews and identify significant gaps in sustainabilty, using the preparation stage Protocol tool.

The complexity in the Batoka Gorge case lay in the transboundary nature of the assessment. This entailed the involvement of a large number of stakeholders with diverging interests. A key outcome of the process was the development of a communications strategy for stakeholder engagement.

Further downstream in Mozambique, the Cahora Bassa North scheme has used 20 of the 23 Protocol topics for a preparation stage assessment.

In Vietnam, training has been given to 15 EVN assessors for the internal self-assessment of two projects in the operation stage.

Finally, in the case of Indonesia, the Matenggeng pumped storage project and nearby multipurpose reservoir projects in central Java have used the results of the Protocol to assess risk in resettlement plans, flood control, cultural heritage and indigenous peoples.

A common challenge expressed by all panellists was the difficulty of committing internal staff time to Protocol self-assessment activities.

Flood preparedness

How can the Red Cross and the Red Crescent support the hydropower sector in designing and implementing dam safety measures and policies?

Co-convenor
Red Cross Red Crescent Climate Centre (RCRCCC)

Climate Centre

Understanding the flood risk of extreme weather events can help turn early warnings into early actions to reduce the losses.

The 'Forecast-based Financing' (FbF) programme for flood preparedness is being piloted in West Africa through a digital tool called FUNES.

Volunteers collect rainfall data on the Mono River basin, upstream of the Nangbéto Hydropower Dam, and an innovative hydrological model helps guide the timing and discharge of any imminent dam overspill. This model is based on a self-learning algorithm designed using just three years of data.

This forecast enables dam operators to plan releases, and work with the Red Cross to limit the impact on inundated communities.

When FUNES forecasts flood impacts, the Red Cross, government and partners receive an automated message to activate radio alerts, distribute water purification tablets, and deploy other pre-funded disaster preparedness measures.

The system was successfully tested in September 2016, and received the 2017 Global Innovation Award from the World Government Summit.

Speakers

- **Pablo Suárez,** Associate Director for Research and Innovation, Red Cross Red Crescent Climate Centre

With closer collaboration with the hydropower sector, the Red Cross could improve its emergency preparedness plans, making them more effective and allocating funds in a smarter way.


Pablo Suárez

The Red Cross has created a virtual reality experience to demonstrate the complexity of being a Red Cross disaster risk manager.

This informal lunchtime session brought together disaster managers, donors, dam operators, government officials, researchers, and machine learning experts. Participants explored new approaches to flood risk management downstream of dams, focusing on two promising developments: FbF and machine learning.

Key discussion points

Pablo Suárez explained how he envisages the collaboration between the hydropower and the humanitarian sectors to plan early humanitarian action in flood events.

The humanitarian sector typically releases funds when disasters have already happened. With closer collaboration with the hydropower sector, the Red Cross could improve its emergency preparedness plans, making them more effective and allocating funds in a smarter way.

Mr Suárez described the successful collaboration between the Nangbéto dam operator, the Togo government and the Togo Red Cross, using funding from the World Bank Group and other donors.

The Red Cross has created and tested a new approach to forecasting called FUNES, a self-learning algorithm, due to a lack of data, which uses rainfall information collected by Red Cross volunteers to forecast runoff. This information was validated by the operator, and used to inform the Red Cross when releases would happen.

If the system predicted a high likelihood of flooding downstream, the FbF mechanism would be initiated. This meant that information from the dam could be used to prompt early action from the Red Cross, which could result in saving lives and reducing costs.

The collaboration between the hydropower and humanitarian sectors depends on a combination of forecasting, decision-making, legal/institutional frameworks and early action.

The Red Cross has created a virtual reality experience to demonstrate the complexity of being a Red Cross disaster risk manager. This system enables hydropower operators to better understand how to set up a danger level at a dam where flooding is likely to happen downstream, and use this to inform the Red Cross to take early action (eg early warnings, evacuation plans, water purification, building shelters, etc.). The virtual reality experience was demonstrated in the showcase area of the congress venue.

The hydropower community can also get additional benefits from this

collaboration: Red Cross volunteer network supporting data collection on the ground to improve forecast; awareness that hydropower can lessen extreme precipitation events is disseminated; data collection protocols for the dam are established, benefiting humanitarian action; and funding for risk reduction and disaster preparedness is released in a timely way, within the window of opportunity between the forecast and the potential disaster.

Key outcomes

The hydropower sector and the Red Cross and Red Crescent could work in partnership to trigger early actions to reduce the risk of disasters.

Hydropower operators would inform the Red Cross of the danger level of their reservoirs and any planned releases. The Red Cross, meanwhile, can raise awareness of the benefits of hydropower's storage capabilities for controlling and lessening the risk of flooding.

2017: HARNESSING THE DEMOGRAPHIC DIVIDEND THROUGH INVESTMENTS IN YOUTH

The 2017 World Hydropower Congress will engage and empower the youth of Africa towards the realisation of the African Union theme of the year 2017 and Agenda 2063.

Participate with our youth engagement around the congress using the hashtag **#AUYouth2017**.

Good governance

Co-convenor
Transparency International

Leadership in corporate governance is considered essential to the successful development of hydropower projects.

There is increasing emphasis on promoting the principles of transparency, integrity, accountability and stakeholder engagement for good governance.

In the hydropower sector, these issues are particularly relevant due to the number and size of contracts that hydropower projects can involve.

This informal lunchtime session provided an opportunity to discuss initiatives within Transparency International's Business Integrity Program in relation to promoting integrity. The discussions focused particularly on state-owned enterprises (SOEs).

Key discussion points

Donal O'Leary outlined Transparency International's work on developing principles for countering corruption in state-owned enterprises. He explained why this work is relevant to the hydropower sector.

This multi-stakeholder initiative has developed 10 principles which cover aspects such as transparency, building a trust-based and inclusive culture, and carrying out regular risk assessments.

These draft principles are the subject of a public consultation, which closes in August. The document, entitled 'Anti-corruption Principles for

Speakers

- **Tammy Chu,** Managing Director, Entura
- **Gil Maranhão Neto,** Chief Strategy, Communications and CSR Officer, Engie Brasil
- **Abel Didier Tella,** Director General, Association of Power Utilities of Africa (APUA)
- **Eduard Wojczynski,** Principal, EW Sustainable Hydropower Consulting
- **Donal O'Leary,** Senior Adviser, Transparency International (moderator)

Like private companies, state-owned firms are susceptible to conflicts of interest and are required to develop robust governance mechanisms.


Eduard Wojczysnki

Donal O'Leary outlined Transparency International's work on developing principles for countering corruption in state-owned enterprises.

State-Owned Enterprises', along with supporting materials, is scheduled to be launched by Transparency International in November this year.

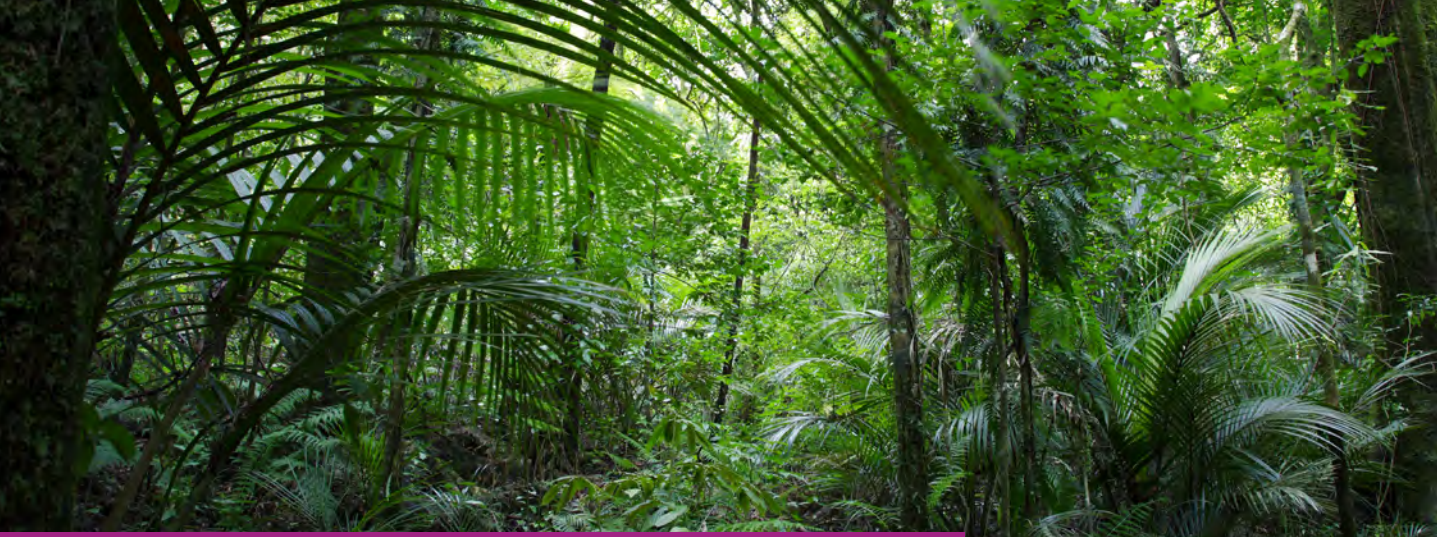
Following Mr O'Leary's presentation, all panellists were asked how their companies and associations are working to foster good governance. They looked at how Transparency International's draft principles could work in practice and what aspects would need further exploration as part of the consultation process.

Key outcomes

SOEs include some of the largest companies in the world, employing millions of people and controlling vital pieces of infrastructure, such as hydropower plants.

Like private companies, state-owned firms are susceptible to conflicts of interest and are required to develop robust governance mechanisms. As such, it is important that initiatives and tools are developed to reduce such risks.

In particular, they noted the importance of SOEs to carry out due diligence to ensure that all the organisations they enter into contract with (including sub-contractors) adhere to the same anti-corruption principles that the SOEs adhere to.



Productivity and forest restoration

Co-convenors

The Nature Conservancy

Conservation International

Climate Policy Initiative

Hydropower operators are being impacted across tropical basins due to heavy sedimentation and increased climate variability.

Recent research by Conservation International shows strong potential for cloud forest restoration, which would enhance water volumes, regulate flows and reduce sedimentation.

The Cloud Forest Blue Energy Mechanism (CFBEM) is an innovative financing instrument currently under development by Conservation International and The Nature Conservancy. The initiative would share the costs, risks and benefits of restoration between operators and investors.

The initiative has been selected as one of the top three ideas for the Global Innovation Lab for Climate Finance this year, based on its potential for replication and financial sustainability.

This informal lunchtime session introduced the Cloud Forest Blue Energy Mechanism, and was an opportunity for discussion on how such a scheme can be structured in different watersheds around the world, with perspectives from leading scientific, technical and financial experts.

Key discussion points

Justus Raepple presented the cloud forest conservation challenge and how and why the hydropower sector should be involved. He explained that 50 per cent of cloud forests were located in hydropower basins.

Speakers

- **Gabriel Azevedo,** Head of Environment, Social and Governance Division, Inter-American Investment Corporation (IIC)
- **Angela Falconer,** Associate Director, Climate Finance, Climate Policy Initiative
- **Justus Raepple,** Deal Lead, NatureVest, The Nature Conservancy

The congress was a good opportunity to understand challenges in the hydropower sector and identify interest among operators, who were identified as key partners in the restoration and conservation of cloud forests around the world.


Angela Falconer

The CFBEM aims to provide upfront financing for the conservation or restoration of cloud forest throughout the world. Hydropower operators would repay and finance the conservation when the benefits are delivered.

The benefits to the hydropower sector are multiple. The conservation of cloud forest can help reduce sediment erosion, increase water flow, because of the moisture capture, and regulate water flow. As such, cloud forest restoration can reduce the increasing variability of hydrological patterns. These benefits translate into higher flexibility in energy dispatch, an increase in operators' revenue and more resilience to climate change. Operators would only pay when the benefits are delivered, which could take several years.

Angela Falconer went into more depth on the financial instrument. The CFBEM goes beyond other financial mechanisms such as the Payment for Ecosystem Services (PES), compensation or offset mechanisms and corporate social responsibility (CSR) because it makes the business case for forest restoration in terms of the direct measured benefits for hydropower operators. The initiative will be financially sustainable providing those benefits are delivered.

The Climate Policy Initiative is carrying out research and offering support to identify effective energy and land use policies with a focus on finance.

The Global Innovation Lab for Climate Finance is helping develop the business case for the CFBEM and will eventually pilot the instrument.

The congress was a good opportunity to understand challenges in the hydropower sector and identify interest among operators, who were identified as key partners in the restoration and conservation of cloud forests around the world.

Key outcomes

The mechanism is now looking to be translated into a pilot project. Countries considered include Colombia, Peru and Brazil, but the promoters are also seeking interested developers and operators in other regions with cloud forests, including Africa.

Monitoring and measuring benefits was deemed to be essential to make the mechanism work. Hydropower operators present in the audience concurred. This was an important part of the discussion as interest from operators will be key for the financial sustainability and success of the mechanism.

Francophone hydropower community

Co-convenor
Francophone Institute for Sustainable Development

A large number of states and governments active in the development of hydropower are also members of the Francophonie; nevertheless, exchanges of good practice in the sector generally remain conducted in English.

IHA and the Francophone Institute for Sustainable Development (IFDD) examined this finding by co-organising a special session at the World Hydropower Congress.

The IFDD and IHA wanted to explore the avenues of collaboration to facilitate knowledge-sharing and capacity-building with key players within Francophonie member states. The session was attended by representatives of governments, public and private enterprises, and non-governmental organisations from four continents. Participants were able to share their recommendations and identify priorities for the sustainable development of hydropower facilities and associated infrastructure in their respective countries.

The first observation was that the member states and governments of the Francophonie account for nearly 15 per cent of the installed hydroelectric capacity in the world. This figure is intended to remain stable and even increase if some countries implement their most ambitious development plans: Guinea, Côte d'Ivoire, Democratic Republic of the Congo,

Speakers

- **Christine Cantin,** Principal Advisor, Hydro-Québec
- **Jean-Pierre Ndoutoum,** Director, Francophone Institute for Sustainable Development (IFDD)
- **Greg Tracz,** Chief Development Officer, International Hydropower Assocation (IHA)

On a number of issues, participants expressed the need for support, particularly with regard to local community engagement, environmental good practices more generally, and the resilience of hydroelectric infrastructures to climate change.


Jean-Pierre Ndoutoum

among others, each aim to add several thousand megawatts of hydroelectric capacity in the medium term.

It was also highlighted by the participants that the Francophonie is not limited to the use of a common language but embraces a shared vision for the social and environmental issues of our time, the responses that can be provided and the values that should guide public action, including solidarity, cultural diversity and education.

This provides the context for the activities of the IFDD. Jean-Pierre Ndoutoum, Director, reminded participants of the role of the institute, a subsidiary organ of the International Organisation of the Francophonie (OIF), established in 1988. The IFDD contributes to, among other things, the promotion of practical tools related to sustainable development. In this capacity, it plays an important role in the accomplishment of one of the four missions of the Francophonie, centred on sustainable development, economy and solidarity.

The three main lines of work of the IFDD were introduced: (1) strengthening the participation of francophone countries in international negotiations; (2) information and communication; and (3) integrating sustainable development objectives into regional and national policies and strategies. On these two points, Jean-Pierre Ndoutoum felt that the synergies were strong with IHA.

Christine Cantin of Hydro-Québec, for her part, stressed the diversity of points of view represented within the association. In addition to operators and historical developers, new players have recently joined the association, as well as research institutes, regional and national associations. In addition, IHA partners include non-governmental organisations as well as governments and financial institutions. All contribute to the development and sharing of knowledge on the association's work programme.

On a number of issues, participants expressed the need for support, particularly with regard to local community engagement, environmental good practices more generally, and the resilience of hydroelectric infrastructures to climate change.

Discussions during the session also highlighted the importance of topics that were perceived as insufficiently covered by institutions working in the energy sector, in particular the participation of young people and the creation of training programmes specifically designed for young engineers in the francophone developing countries.

Participants finally identified the opportunities that exist and could be used for the benefit of the francophone countries involved in hydroelectricity. The IFDD and IHA have committed to exchange more information with their respective networks and to work towards the organisation of joint awareness-raising activities before the next World Hydropower Congress to be held in Paris, where the OIF is headquartered.

Francesca Antonelli, WWF, speaking from the audience

Closing plenary

The congress concluded with commitments to better hydro, delivered by a broad range of organisations and institutions that supported and participated in the event.

Convenor
International Hydropower Association

Speakers

- **Archana Agrawal,** Joint Secretary, Ministry of Power, India
- **Ken Adams**, President, International Hydropower Association
- **Gabriel Azevedo**, Head of Environment, Social and Governance, Inter-American Investment Corporation
- **Antoine Badinier**, Deputy Vice-President, EDF Hydropower Generation & Engineering
- **Lin Chuxue**, Executive Vice-President, China Three Gorges
- **Heike Bergman**, Senior Vice-President, Sales Africa, Voith Hydro
- **Linus Mofor,** Senior Environmental Affairs Officer, UN Economic Commission for Africa
- **Cheick Ould Bedda,** Director, Infrastructure and Energy, African Union Commission
- **Guo Ricai**, Co-President, China Electric Power Equipment and Technology Corporation
- **Zhou Xiong**, General Manager, Shandong Electrical Engineering and Equipment Group
- **Liang Xuming**, Chief Engineer, Global Energy Interconnection Development and Cooperation Organisation

Other interventions

- **Francesca Antonelli,** Rivers and Infrastructure Coordinator, WWF
- **Ralph Olaye**, Director, Business Development, Eranove
- **Marie-Claire Paiz**, Programme Director, Gabon, The Nature Conservancy

Joint Secretary Archana Agrawal of India led the session with an acknowledgement of the "great and ambitious plans for Africa, the rising giant for hydropower" and first-time host of the congress. She expressed her interest in witnessing the sustainable energy transformation of the continent.

Representing the Economic Commission for Africa (ECA), Linus Mofor, called for climate resilience to be fully integrated into better hydro and for better hydro to be elevated to high-level policy makers. He also expressed support to improving information on hydropower benefits.

Cheick Ould Bedda praised the successful congress as "a world class event" and confirmed the commitment of the African Union Commission and the entire African continent towards better hydro.

A series of commitments by organisations followed, beginning with congress organising partner GEIDCO, represented by Liang Xuming. He confirmed the organisation's commitment to faster implementation of global energy interconnection (GEI), and particularly to improving electrification and building a sustainable energy future for Africa.

Antoine Badinier, of EDF, credited Ethiopia and all of the African countries in their efforts to promote sustainable energy. Announcing the support of his organiation to the 2019 World Hydropower Congress in Paris, he expressed the need to modernise our energy systems, a statement supported by Robin Goodman. On behalf of equipment providers, Robin Goodman (GE) and Heike Bergmann (Voith Hydro) expressed their support to capacity building, in particular in Africa.

A commitment from China Three Gorges Corporation (CTG) followed, delivered by Lin Chuxue, who declared CTG's continued commitment to supporting the World Hydropower Congress. He described the company's commitment to building expertise and capabilities, together with IHA, NGOs and development agencies, to assist African countries in harnessing their water and


Archana Agrawal


Antoine Badinier


Lin Chuxue

hydropower resources in a sustainable way.

Guo Ricai, of China Electric Power Equipment and Technology Corporation, expressed the need to "improve interconnection and boost the construction of cross-continental and national smart grids", and reaffirmed his company's commitment to the World Hydropower Congress and the better hydro cause. Zhou Xion, speaking on behalf of Shandong Electrical Engineering and Equipment

"The congress demonstrated how key players are each doing their part to tackle the huge challenges ahead of us" - **Ken Adams,** President, International Hydropower Association


Participants in the closing session

Group, expressed his desire that the hydropower community would "join hands and work together to achieve the sustainable development of hydro in an interconnected world".

Gabriel Azevedo described the need for solid partnerships. He reminded delegates that "stakeholders that used to oppose or fear each other are now partners, committed to delivering better hydro together". He concluded by calling on the hydropower community to "commit to the development of better hydro not as an objective but as a means to contribute to a better and more sustainable world for future generations".

Speaking from the audience, a number of organisations expressed their thanks to the organisers and formulated commitments towards better hydro.

The Nature Conservancy was represented by its programme director for Gabon, Marie-Claire Paiz, who expressed support to the principle of developing "the right projects, in the right place and in the right way" and described the new tools and approaches being designed to reduce the environmental, social and financial risks at the early stages of hydropower development. In particular, she emphasized the commitment of her organisation to early planning (Hydropower by Design), strategic environmental assessment, sustainability assessment performance and the integration of hydropower with other renewable energy sources.

On behalf of the WWF network, Francesca Antonelli, Rivers and Infrastructure Coordinator, expressed her organisation's commitment to enhancing the widespread use of the Hydropower Sustainabiity Assessment Protocol. She also described WWF's commitment to monitoring developments to ensure that valuable natural assets are protected for the venefit of people and nature, and fostering the application of system-scale planning for making "inclusive, prior and well-informed choices".

Ken Adams, president of IHA, closed the session and announced the launch of the Better Hydro Compendium of Case Studies 2017, a collection of examples of good practice in sustainable hydropower. He highlighted the fact that "the Better Hydro compendium shows it can be done well, it can be done right" and described how the exchanges of the congress showed that key players were "each doing their part to tackle the huge challenges ahead of us".

Ken Adams confirmed that the next World Hydropower Congress would take place in Paris, France in 2019.

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SHANDONG ELECTRICAL ENGINEERING & EQUIPMENT GROUP CO., LTD.

Shandong Electrical Engineering & Equipment Group Co.,Ltd.(SDEE) is the direct subsidiary of State Grid Coporation of China(SGCC). Its core business covers tansformers, towers, wires and cables, GIS, smart distribution gird, smart power equipment, it is the largest domestic electrical equipment and overall solution supplier.

Based on services for "the Belt and Road Initiative" and the global energy interconnection construction, SDEE accelerated the pace of scientific and technological innovation, and realized a leap-forward development. SDEE has supplied transmission& distribution equipment and materials for all the UHV projects in China. Followed closely "going abroad strategy" of SGCC, SDEE supported the construction of overseas investment projects, expanded the international power EPC business, and has established a good reputation in the international market.

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Workshops

A series of workshops took place over two days prior to the main congress, on 7 and 8 May. The workshops were organised in partnership with the World Bank Group.

State-of-the-art sediment management practices

Co-convenor
World Bank Group

WORLD BANK GROUP

Improvements in sediment management are being implemented to reduce the loss of reservoir storage capacity resulting from sedimentation.

The workshop explored best practices in implementing sediment management strategies at the planning, operation and maintenance phases of reservoirs, and featured a selection of case studies.

Energy production from hydropower is currently being reduced at a rate of 1 per cent globally due to the loss of reservoir storage capacity resulting from sedimentation.

Sediment management strategies seek to maintain the sustainability of reservoirs, extending benefits such as energy and water supply and flood protection in the long term.

Nature-Based Infrastructures (NBI) offer considerable potential to reduce erosion rates in the watershed. In addition, NBI can offer further benefits to those associated with multipurpose reservoirs, such as flood protection, water supply, livelihood provisions and, in particular, can reduce the risk of natural disaster.

Following further research to reverse net storage loss, and therefore improve the sustainability of hydropower, the World Bank Group (WBG) published 'Extending the life of reservoirs: sustainable sediment management for dams and run-of-river hydropower'.

Speakers

- **Bill Girling,** Senior Hydropower Sector Analyst, International Hydropower Association (IHA)
- **Guo Qingchao,** Professor, China Institute of Water Resources & Hydropower Research
- **Pravin Karki,** Senior Hydropower Specialist, World Bank Group
- **Gregory Morris,** Consultant, GLM Engineering COOP
- **Pratik Man Singh Pradhan,** Vice President, Butwal Power Company
- **Ajay Pradhan,** President and CEO, Cetus Consulting Solution Services
- **Siri Stokseth,** R&D Manager and Dam Safety Coordinator, Statkraft
- **Gete Zeleke,** Director, Water and Land Resource Centre - Addis Ababa University (WLRC-AAU)
- **Maria Ubierna,** Hydropower Sector Analyst, International Hydropower Association (IHA; moderator)

Greg Morris stated that reservoirs are a critical natural resource, gradually being lost to sedimentation. And because this is a slow process, it is not receiving the attention it deserves.


Greg Morris

Sediment management strategies seek to maintain the sustainability of reservoirs, extending benefits such as energy and water supply and flood protection in the long term.


Guo Qingchao

Subsequently, the bank launched a new initiative to collect and identify criteria based on case studies to assist in pre-feasibility level decision-making on sediment management.

IHA, with support from the World Bank Group, is currently developing a website on sediment management, which will feature a collection of case studies. The website and a summary of the case studies was presented during the workshop. The aim of this initiative is to further explore best practices in sediment management for implementation at the planning, operation and maintenance phases of reservoirs with hydropower as one of their main purposes.

Key discussion points

Pravin Karki and Bill Girling's introduction emphasised the significant threat sedimentation poses to sustainable hydropower. The World Bank Group is therefore keen to promote sediment management practices that will extend the life of reservoirs. The aim is to include these practices into new designs to sustain the functionality of the reservoir in the long term. Sediment management will remain a work priority for IHA.

Greg Morris stated that reservoirs are a critical natural resource, gradually being lost to sedimentation. And because this is a slow process, it is not receiving the attention it deserves. Nevertheless, maintaining the long-term storage capacity of a reservoir to maximise usable storage for as long as possible is critical. Deposited sediment volume can rarely be recovered, and reservoirs cannot simply be replaced.

There are a number of options for addressing sedimentation, some more affordable to implement than others.

The options for sediment management vary according to the site and over time.

Monitoring is essential for understanding the impact of sedimentation and for selecting the best strategy.

In a series of case studies, speakers described their experiences of sediment management.

Siri Stokseth emphasised the need for measurements and consistent data collection to calculate the costs associated with loss of production and redesign works of existing plants.


Gete Zeleke

Guo Qingchao focused on sediment simulation in the Yellow River basin.

Gete Zeleke explained the watershed management approach for upstream control of soil erosion that his team has been applying in the Nile basin in northern Ethiopia.

Ajay Pradhan and Pratik Pradhan presented two run-of-river projects in India and Nepal respectively, focusing on the challenges faced by this type of hydropower project in highly-erodible areas such as the Himalayas.

Finally, Greg Morris presented the RESCON2 tool beta version. This is a screening tool to identify which sediment management strategy is the most technically and economically feasible, and how to maximise economic performance. The final version is expected within the next two years.

In the second part of the workshop, participants divided into three breakout sessions: watershed management; implementation of sediment management practices; and monitoring.


Pravin Karki


Bill Girling

Key outcomes

Sediment management will remain a work priority for IHA. Together with the World Bank Group, IHA is documenting successful sediment management practices, which will be available on our website, hydropower.org.

Every reservoir needs a long-term sustainability strategy. As such it is important to share knowledge on sediment management practices.

Gete Zeleke explained the watershed management approach for upstream control of soil erosion that his team has applied in the Nile basin in northern Ethiopia.

Real-time monitoring is essential for understanding the impact of sediment management and how to best control it.

The outcomes of the breakout sessions were as follows:

Watershed management

- All stakeholders have to be involved from an early stage of the project, because each has a stake in the catchment.
- The traditional use of the land also needs to be taken into consideration. Responsibility and benefit must be shared between everyone in order to maintain sustainability.
- Policy-makers must develop a comprehensive planning approach that takes place in conjunction with strategic river basin planning.
- A shift is necessary in engineering education to include participatory skills as well as a nature-focused approach to understanding local ecosystems.
- Detailed cost of sediment management strategies like watershed management and land use restoration to reduce the soil erosion upstream has to be accounted for as part of the total cost of hydropower projects.

Implementation of sediment management strategies

- A holistic catchment approach is the best option for adequately managing sedimentation. This would address the transboundary effects and allow for the optimisation of hydropower generation, ecological effects and other anthropogenic aspects of sedimentation. However, it does entail complications, such as responsibility and accountability for the sediment.

- Trade-offs must be properly understood and communicated to all stakeholders.
- In terms of the reuse of removed sediment, the option of cost-effective bricks made from dredged sediment was presented. The monetisation of sediment management approaches was briefly discussed.

Monitoring and sharing information

- Effective and reliable monitoring of sediment is essential to enable proper management.
- A monitoring plan should be drawn up during the construction/design of the plant. This should take into account the frequency of monitoring, depending on climate, location, seasonal changes, etc.
- Data that is not displayed or used is worthless.
- For multipurpose dams, there needs to be better management with all stakeholders over the long term.

Hydropower and dam safety management

Co-convenor
World Bank Group

WORLD BANK GROUP

The safe operation of dams has significant social, economic, and environmental relevance given the considerable portfolio of ageing large dams worldwide.

Dam safety is unique in that it represents a low-probability event with severe consequences or hazard risks.

Dam failures, however rare, can result in extreme adverse impacts, including large-scale loss of human life.

For countries with large stocks of dams, the existence of appropriate and effective legal, regulatory and institutional frameworks is critical.

This workshop focused on the essential elements of the regulatory regime and specific approaches to risk management, as covered in the ongoing study 'Comparative study of the legal and institutional frameworks for dam safety management', being carried out by the World Bank Group and the University of South Australia.

The workshop featured three examples from a sample of the 51 country case studies in the report, and explored the range of options available to countries for effective dam safety management.

Speakers

- **Kimberly Lyon,** Water Resources Management Analyst, World Bank Group
- **Satoru Ueda,** Lead Dam Specialist, World Bank Group
- **Ato Kebede,** State Minister, Ministry of Water, Irrigation and Energy
- **Chen Guanfu,** Executive Vice President, POWERCHINA
- **Mohamed Amahdouk,** Hydraulic Administration, Ministry of Energy, Morocco
- **Bill Girling,** Senior Hydropower Sector Analyst, International Hydropower Association (IHA; moderator)

Kimberly Lyon highlighted how the World Bank Group is trying to address dam safety issues, and help enhance its clients' overall systems and capacity.


Kimberly Lyon


Satoru Ueda


Chen Guanfu


Bill Girling

Key discussion points

The representatives from the World Bank Group gave an overview of dams and historical trends around the world, followed by a review of recent dam failures and incidents. This served to highlight some systematic dam safety issues.

Kimberly Lyon introduced the World Bank Group's portfolio and the types of support available for dam safety (lending, technical assistance).

She highlighted how the World Bank Group is trying to address dam safety issues, and help enhance its clients' overall systems and capacity.

Finally, she discussed some of the typical dam safety issues observed in World Bank Group client countries. She described how the bank is trying to address these issues, either on a project basis or through broader dam safety management system/capacity-building activities.

The 'Global Comparative Dam Safety Study' was introduced, with case study countries, phases and outputs.

The study elaborates on six key topics, along with key sub-topics being assessed through 51 country case studies:

1. Legal basis for dam safety responsibility and legislation: types of legal system (civil law or common law); possible level(s) of law-making for dam safety (national only or federal/state/provincial); laws defining dam safety; and legal responsibility for dam safety (dam owner, manager, regulator or mixed).
2. Governance and institutional arrangements for dam safety assurance: regulators vs owners/operators; ownership (public, semi-public, or private); and administration levels.
3. Regulatory schemes: scope and definition of regulated dams; dam classification and the associated level of safety requirements; issuance of licences/permits for constructing dams regarding dam safety and third-party review mechanism; design standards/criteria under regulations or reference to other standards; compliance monitoring (including enforcement strength); and reporting and auditing procedures.

4. Funding mechanisms for dam safety: sources of funding for the administration of the dam safety regulatory scheme; operations and maintenance budget sources and adequacy; cost allocation; cross-subsidies between different purposes in the case of multipurpose dams; and funds for periodic major rehabilitation works and safety upgrades.
5. Operations and maintenance: corporate governance; portfolio risk management; and institutional capacity.
6. Emergency preparedness plan (EPP) and dams on transboundary rivers.

Three case studies were presented to offer an overview of the current state of dam safety legislation and dam safety practices in Ethiopia, China and Morocco.

They addressed the unique institutional challenges each of these countries is facing in terms of implementing dam safety guidelines and emergency preparedness plans (EPP).

The challenges were quite similar in all three cases, including: insufficient monitoring and data analysis; low frequency of inspection; lack of regulation; no specific dam safety legislation; and a lack of finance for operations and maintenance.

Three case studies were presented at the workshop to offer an overview of the current state of dam safety legislation and dam safety practices in Ethiopia, China and Morocco. They addressed the unique institutional challenges each of these countries is facing in terms of implementing dam safety guidelines and emergency preparedness plans (EPP).

The case studies illustrated the need for a number of measures, including: a more detailed regulatory framework; the formation of advisory panels; sustainable finance for construction; risk-informed approaches; portfolio risk management (moving away from a traditional standard-based approach); and continued financial assistance from the World Bank Group and other lending institutions.

Other lessons learned during the workshop included: the need to address risk properly; the importance of setting appropriate safety criteria; building local knowledge; and the need to bring in international experience for preparing operations and maintenance plans.

Key outcomes

Discussions in the workshop highlighted the following:

- A lack of ministerial cooperation can jeopardise well-intended projects.
- There is a need for better communication in the case of emergency situations to ensure that support is deliverted promptly and efficiently. International organisations can help develop guidance for crisis situations.
- It is important to carry out regular equipment maintenance in order to avoid catastrophic events.
- Specific regulatory schemes for dams are not always present, but they're not always necessary. In New Zealand, for example, the Building Act of 1991 does not have any provisions dealing with dam safety, but deals with building safety in general.
- Due to a lack of permits issued, owners of dams are often left fully responsible.
- Funding is needed to support maintenance and safety. This is particularly relevant in countries with less hydropower.
- There is a general lack of ministerial and overall cross-sectoral collaboration.
- Further capacity-building and collaboration is needed between stakeholders.
- More preparation is required, to be supported by the introduction of a financial mechanism.
- There should be a bridging of opportunities between communities and governments.


Satoru Ueda

Climate resilience for hydropower projects

Co-convenor
World Bank Group

WORLD BANK GROUP

Many countries are seeking to gain a better understanding of the impacts of climate change - both positive and negative - and are beginning to build strategies and approaches to incorporate climate resilience into their plans.

A likely next step for partners working in this field is to develop sector guidelines both for climate change adaptation services and for the incorporation of climate resilience into existing hydropower facilities and modernisation projects.

To address this risk, the World Bank Group has launched an initiative that aims to produce a practical set of climate resilience guidelines. These would be designed to ensure that both existing and future hydropower projects are resilient to climate change.

This workshop was an opportunity to hear about good practices from key global players. It also introduced the proposed guidelines for building climate resilience into both planned and existing hydropower projects.

Representatives from developed and developing countries presented their own experiences of the central role climate resilience plays in hydropower development within their jurisdictions.

Speakers

- Pravin Karki, Senior Hydropower Specialist, World Bank Group
- Raffaello Cervigni, Lead Environmental Economist, World Bank Group
- Bruno Trouille, Senior Hydropower Specialist, Mott MacDonald
- Gabriel Azevedo, Head of Environment, Social and Governance Division, Inter-American Investment Corporation (IIC)
- Marco Braun, Hydroclimatology Specialist, Ouranos
- Linus Mofor, Senior Expert, UNECA - African Climate Policy Centre
- Divas Basynat, Senior Water Resources Specialist, Nepal Development Research Institute (NDRI)
- Tammy Chu, Managing Director, Entura
- Bill Girling, Senior Hydropower Sector Analyst, International Hydropower Association (IHA; moderator)

Divas Basnyat described the challenges the Nepalese government is facing in making decisions about hydropower development now, that will remain robust and build resilience 25 to 30 years on.


Divas Basnyat

This workshop introduced the proposed guidelines for building climate resilience into both planned and existing hydropower projects.


Bruno Trouille

Key discussion points

Keynote speaker Pravin Karki of the World Bank Group set out the importance of work on climate resilience for the hydropower sector.

Building climate resilience into hydropower and dam infrastructure investment is essential. The long lifespan of this infrastructure can make it vulnerable to future, uncertain changes in climate.

This risk has led the funders of the World Bank Group's International Development Agency (IDA) to establish a policy priority for ensuring the resilience of these infrastructure investments.

Through a video intervention, Raffaello Cervigni offered his perspectives on the Programme for Infrastructure Development in Africa (PIDA) programme, addressing in particular the challenges in the water sectors and roads.

Investments for climate resilience vary significantly according to different future projections and under different climate scenarios (eg precipitation), which ultimately affects the design of the infrastructure.

Gabriel Azevedo spoke about climate resilience from the perspective of the Latin American companies IIC works with. He pointed out that some Latin American countries are particularly vulnerable to climate change due to their geography, population, infrastructure setup (or lack thereof), their fragile natural resources for economic activities and livelihoods; and because they are located between two continental masses and oceans, affected by El Niño, etc.

According to Mr Azevedo, there is no common understanding among policy-makers around the terms 'mitigation', 'adaptation', and 'resilience'.

Effort is needed to clarify and define these terms. At COP21, resilience in the energy sector was understood to refer to robustness, resourcefulness and recovery.

Mr Azevedo suggested a number of issues to consider when thinking about climate resilience:

- Technology and information: developing regional climate models; information systems; climate monitoring networks; multidisciplinary studies; and training and capacity building.


Bill Girling, Bruno Trouille, Pravin Karki, Tammy Chu, Gabriel Azevedo, Marco Braun, Linus Mofor

- Portfolio of adaptation projects: increasing the reliability of existing systems through grid integration and cooperation measures, in particular in central America.
- Consider climate change at the design level: systems should be flexible, integrated with renewables, reduce water consumption and maximise water efficiency. Also consider seasonal challenges and storage capacity. For example, run-of-river projects may encounter difficulties in the future if the frequency of the high-extreme precipitation rises, resulting in more vulnerable systems.
- Institutional issues: the role of governments; and providing incentives for greater private sector participation.

Marco Braun of the Canadian climate research consortium, Ouranos, described some of the barriers organisations in developed countries face in terms of developing resilient infrastructure, including:

- The understanding and perception of climate change risks.
- Accessing climate data and climate model projections.
- Understanding and quantifying climate projection uncertainty.
- Communicating between experts of various backgrounds.
- The limitations of existing climate modelling tools.


Gabriel Azevedo


Marco Braun (left) and Linus Mofor

Linus Mofor detailed the resilience measures being implemented in the Sanaga basin in Cameroon, including enhancing the effects of existing storage, developing additional storage and regulating generation, such as through the Lom Pangar dam, currently under construction.


Bill Girling

Bruno Trouille introduced the work Mott MacDonald is involved in to develop guidelines, based on a programme of six phases in building climate resilience into hydropower and dam infrastructure. He emphasised that stakeholder engagement is critical to the process and runs through all six phases.

In addition, it is important to consider economic or financial performance throughout the process, to ensure that resilience measures are viable.

A key step towards evaluating the vulnerability of a project or system to climate risks can be through a climate stress test with a defined threshold.

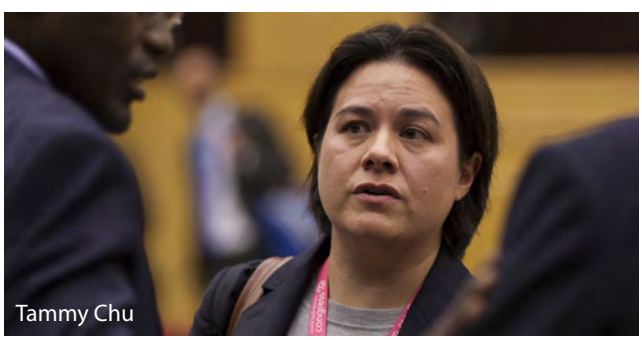
Three case studies were presented from various regions, illustrating the climate resilience measures these countries have implemented and some of the challenges they face.

Divas Basnyat spoke of the challenges Nepal is facing in terms of understanding the complex nature of climate variability in the country. He also described the challenges the government faces in making decisions about hydropower development now, that will remain robust and build resilience 25 to 30 years on.

Nepal is exploring the idea of a national authority that could develop a river basin plan so the projects would consider both the upstream and downstream impacts.

Tammy Chu presented an integrated system approach to addressing vulnerability in Tasmania.


Marco Braun


Tammy Chu

Practical guidelines are needed to achieve climate resilience in the planning, design, construction and operation of new projects, as well as during reviews and assessments of operational performance, rehabilitation and upgrade of existing projects.

Hydro Tasmania has had strategies in place for responding to climate change since 2007, and has been implementing climate-future projections since then.

She described the different elements of building resilience, including: upgrades and maintenance of power stations; drought management procedures; emergency management planning to address flood-related risks; and bushfire and extreme weather events.

All of these plans proved efficient during the year 2015/2016, when Tasmania suffered a long summer drought together with bushfires, followed by historic high floods.

Linus Mofor presented the experiences of the Sanaga basin in Cameroon, which represents 6 GW of hydropower potential, 50 per cent of the country's total.

He detailed the resilience measures being implemented, including enhancing the effects of existing storage, developing additional storage and regulating generation, such as through the Lom Pangar dam, currently under construction.

Key outcomes

Organisations need to consider building resilience to climate change into the design level of hydropower projects, by:

- Developing flexible hydropower systems that emphasise joint operation.
- Developing energy generation systems that are integrated with other renewables (eg wind, solar, and biomass).
- Designing hydropower systems that focus on reducing water consumption as much as possible through the greatest usable head (technically and economically viable).
- Design hydropower systems that consider seasonal storage capacity to compensate for flow reduction.
- Participants also agreed that climate change is an opportunity for hydropower to play a more prominent role in hybrid systems.

A number of comments were raised relating to the draft climate resilience guidelines:

- Regional consortia would help to facilitate building climate change resilience into hydropower.
- Climate services are available for customised data, expertise and capacity-building.
- Adaptation or implementation of adequate tools (eg hydro models, decision-making approaches) is a necessary initial step in the process.
- Climate resilience should be viewed in a similar way to conventional risk assessment, requiring new approaches and data.
- Upstream climate science needs to be connected with downstream engineering practices.
- Practical guidelines are needed to achieve climate resilience in the planning, design, construction and operation of new projects, as well as during reviews and assessments of operational performance, rehabilitation and upgrade of existing projects.
- It is important to identify and evaluate robust approaches for planning, evaluating, and designing hydro-specific infrastructure investments.
- A guidance document should be aimed at those responsible for the planning, funding, development, construction and operation of hydropower projects in all regions of the world.
- Both the functional and structural adaptation need to be assessed.

Operations and maintenance

Co-convenor
World Bank Group

WORLD BANK GROUP

A lack of dedicated resources, proper training and institutional capacity can result in hydropower generating stations being poorly maintained and operated, particularly in developing countries.

Poor operations and maintenance (O&M) of hydropower facilities can result in significant consequences, such as: high outage rates; performance losses; and rehabilitation/replacement costs.

Ultimately, poor O&M may lead to lost energy production and revenue. More indirect and longer-term impacts of poor O&M can also include dam safety concerns, and public or environmental safety issues. These have the potential to lead to loss of life and property.

This workshop explored different models for the O&M of dams and hydropower generating assets, with a particular emphasis on best practices that can be brought to developing countries.

It is in developing countries where the consequences of poor O&M are often amplified, due to lack of capacity and availability of funds.

The workshop explored a roadmap for tools that could be further developed in order to foster and support sustainable O&M practices in the hydropower sector.

Speakers

- **Guy Bonvin,** Head of Infrastructure Financing Division, Swiss Secretariat of Economic Affairs (SECO)
- **Jean-Michel Devernay,** Consultant, World Bank Group
- **Bill Girling,** Senior Hydropower Sector Analyst, International Hydropower Association (IHA)
- **Robin Goodman,** Hydro Services Leader, GE Renewable Energy
- **Pierre Lorillou,** Senior Hydropower Specialist, Energy and Extractives Practice, World Bank Group
- **Laurent Mouvet,** CEO, Hydro Operations
- **Norbert Riedel,** CTO, Voith Hydro
- **Dominik Godde,** Managing Director, H2GO Consult GmbH (moderator)

Norbert Riedel of Voith Hydro gave an overview of the company's HydroSchool training programmes, which are designed to build capacity and O&M skills in some of Voith's client countries.


Norbert Riedel

It is in developing countries where the consequences of poor O&M are often amplified, due to lack of capacity and availability of funds.


Bill Girling

Key discussion points

Moderating the workshop, Dominik Godde opened the session by explaining the structure and format of the workshop, which focused on three themes in the O&M of hydropower facilities: O&M awareness, O&M strategy, and O&M models.

Guy Bonvin provided a summary of the O&M workshop in Martigny, Switzerland, in October 2016. The main conclusions of that workshop were instrumental in moving this theme forward and sharing experiences from developing countries.

The key messages from the Martigny workshop were:

- Include O&M in the design phase of a hydropower project, including planning for spare parts, developing O&M manuals, giving staff training and ensuring you understand your machinery and equipment.
- Establish a cost-effective tariff, and allow sufficient financial resource to perform O&M activities and investment, ie pay to extend the lifespan of your hydropower asset.
- Promote O&M through marketing, dissemination of knowledge, and through contracts.

Pierre Lorillou outlined the World Bank Group's commitment to enhancing hydropower as a key driver of renewable energy, which ultimately requires adequate O&M of assets.

Mr Lorillou pointed out that the World Bank Group, with the support of SECO, and in collaboration with IHA, is supporting the initiative for Sustainable O&M for Hydropower (SOMH).

This initiative aims to promote best O&M practices and models and foster an integrated approach for adequate services and asset-life management.

Jean-Michel Devernay outlined the consequences of poor O&M, such as:

- loss of revenues caused by high outage rates and loss of performance;
- emergency situations that can be dangerous and expensive to fix;
- high rehabilitation costs, even for relatively recent projects;
- safety issues.

Guy Bonvin

He then described the three models for O&M currently supported through the World Bank Group:

1. O&M in the hands of the owner of the scheme (standard model worldwide).
2. O&M responsibility totally or partially transferred to a private or semi-private independent operator under an O&M (or management) contract with the owner.
3. O&M responsibility entrusted to the EPC contractor, as part of the EPC contract.

While there isn't one single best model which would best fit all situations and projects, over the long term the first model would likely be the cheapest and most sustainable.

Each of the three models was discussed as a topic for the breakout sessions.

Norbert Riedel of Voith Hydro gave an overview of the company's HydroSchool training programmes. These programmes are designed to build capacity and O&M skills in some of Voith's client countries.

He provided examples of the programmes in use in Mount Coffee (Liberia), Cambambe II (Angola), and the Ingula project (South Africa).

Voith's programmes incorporate some of the company's latest digital technologies, such as OnCare AM, an asset management app designed to optimise operating costs, and HyGuardTM, an integral monitoring system for hydropower equipment.


Jean-Michel Devernay


Robin Goodman

Robin Goodman closed the first session with insights from GE Renewable Energy on the transformation towards the 'digital hydropower plant', where digital innovation is enabling better condition-based maintenance and a 10 per cent O&M cost reduction.

Robin Goodman closed the first session with insights from GE Renewable Energy on the transformation towards the 'digital hydropower plant', where digital innovation is enabling better condition-based maintenance and a 10 per cent O&M cost reduction, through:

- maintenance, personnel and lifecycle management tools to drive visibility and performance in real time;
- operations and system optimisation in multi-constraint environments and water systems;
- 3D, virtual reality, tools and training to support optimised staffing and mobilisation, improve local capabilities and knowledge management.

Key outcomes

The workshop provided valuable insight into the key challenges facing hydropower operators, both from a developed country perspective and from a number of less developed countries.

The main points discussed were:

- In developing countries, in particular in Africa and Asia, there remains a significant challenge for developers to institute training and build capacity to ensure industry good practices in O&M are implemented prior to commissioning of a project.
- Adequate financing must be built into the project to ensure that this can be achieved and maintained over the life of the project.
- The three O&M models presented by the World Bank Group were central to the discussions at the workshop; there is a need to follow up on World Bank Group's work to properly document these models and share this information with a wider community.
- Economic decision-making tools remain a priority across the hydropower sector, to guide decision-making for life extension and modernisation of existing assets.
- The digitisation of hydropower systems is increasingly being implemented to enhance digital controls, and improve the performance of hydropower turbines, plants and related equipment. This results in reduced O&M costs, as well as optimised asset management. In addition, digitisation is playing a role in controlling hydropower operations to work together with other renewable resources, such and wind power and solar photovoltaics, to provide increased flexibility and enhanced control for ancillary services (frequency control, balancing services).

What next?

IHA will continue to work closely with its key members and the World Bank Group to advance knowledge of the O&M good practices for the hydropower sector. Some activities planned in the coming period:

1. Case studies will be developed featuring examples of modernisation of existing hydropower assets.
2. IHA will be coordinating work with the World Bank Group to report on case studies illustrating each of the three different models for the operation and maintenance of assets and a proposal for future webinars on the topic.
3. A joint paper on digitisation of hydropower systems is currently being finalised; future work in this space will be planned with other members of the association.

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