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THE BOTTOM LINE

Hydropower development makes an essential contribution to reducing poverty, boosting shared prosperity, and improving sustainability. Water storage associated with some hydropower projects can also make important contributions to water and food security and to climate resilience. The World Bank Group thus uses multiple instruments to support sustainable and responsible hydropower projects of various sizes and types, depending on local need. But hydropower can also carry significant risks that must be carefully managed. The World Bank Group is committed to helping its clients continuously improve the way they approach hydropower so as to better manage its risks and better share the benefits of this renewable resource.

Supporting Hydropower: An Overview of the World Bank Group's Engagement

Why is supporting sustainable hydropower important for the World Bank Group?

Hydropower potential exists where electricity is most needed

In contrast to the industrialized world, where most of the available hydropower resources are being exploited, only a fraction of the hydropower potential of the developing world has been tapped. The United Nations' Sustainable Energy for All (SE4ALL) initiative has identified 20 countries that together account for about two-thirds of the global deficit in access to electricity—some 750 million people in all (World Bank and IEA 2013). Of these 20 countries, 14 have developed less than a third of their hydropower potential—resources that could be harnessed to benefit people who currently lack access to electricity.

Hydropower production is the least-cost method of providing electricity in many developing countries. In addition to being the largest and most readily scalable form of renewable power generation currently available, it is also often the cheapest, with an average levelized cost of $0.03–0.05 per kWh, according to the Intergovernmental Panel on Climate Change (Kumar and others 2011). At such a low cost, hydropower can also compete economically with other large-scale energy generation technologies, such as gas- and coal-fired plants.

Large-scale hydropower is flexible and reliable. Hydropower plants provide an almost instantly available source of power, whereas other large-scale technologies can take hours or even days to raise or lower their output. Hydropower can therefore be used to rapidly balance supply and demand in a national or regional power system, thereby reducing the risk of power cuts for consumers. The need for such system regulation becomes even more critical as more intermittent power sources (such as wind and solar energy) come to supply the system.

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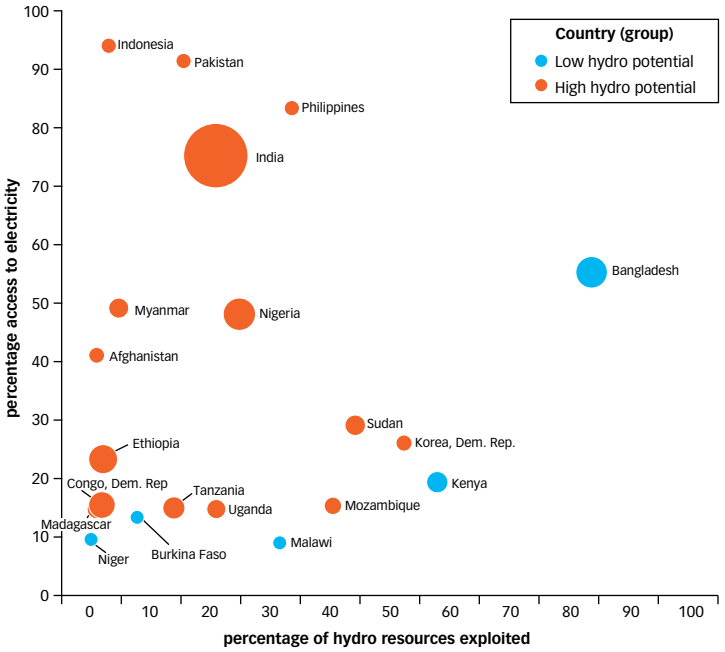
"Hydropower accounts for more than 80 percent of the world's installed renewable power generation capacity, significantly reducing reliance on the fossil fuels responsible for climate change."

Figure 1. Hydropower potential, access to electricity, and access deficit in 20 "high-impact" countries



Source: World Bank and IEA 2013; IJHD 2013.

Note: Size of bubbles indicates deficit in access to electricity. The deficit ranges from 13.6 million people in Malawi to 306.2 million in India.

Hydropower directly helps combat climate change. Currently, hydropower accounts for more than 80 percent of the world's installed renewable power generation capacity (EIA 2013), significantly reducing reliance on the fossil fuels responsible for climate change. The Economist (September 20, 2014) suggests that, globally, hydropower reduces annual emissions by 2.8 billion tons of CO_2 equivalent every year. In addition, multipurpose hydropower delivers benefits from water storage, which improves the security of water supplies for household consumption and irrigation.

However, hydropower can also have significant challenges. Depending on the nature of the project and the way it is managed, it can have negative social and environmental impacts, can be subject to significant cost inflation owing to hydrological or geological surprises, can miss production targets, and can pose safety risks. In its work on hydropower, the World Bank Group focuses on avoiding or mitigating these risks while helping countries capture the wide range of benefits that hydropower offers.

How is the World Bank Group supporting sustainable hydropower?

The World Bank Group has been steadily scaling up its support for hydropower

The direction set in the World Bank's 2003 Water Resources Strategy (World Bank 2004) was confirmed in mid-2013 when the organization's board emphasized the importance of hydropower in combatting extreme poverty in an environmentally and socially sustainable way (World Bank 2013). Over the period 2002–14, World Bank Group funding of more than $8.8 billion has contributed to the installation or restoration of 17 GW of hydropower (figure 2)—enough to meet the energy needs of Belgium.[1]

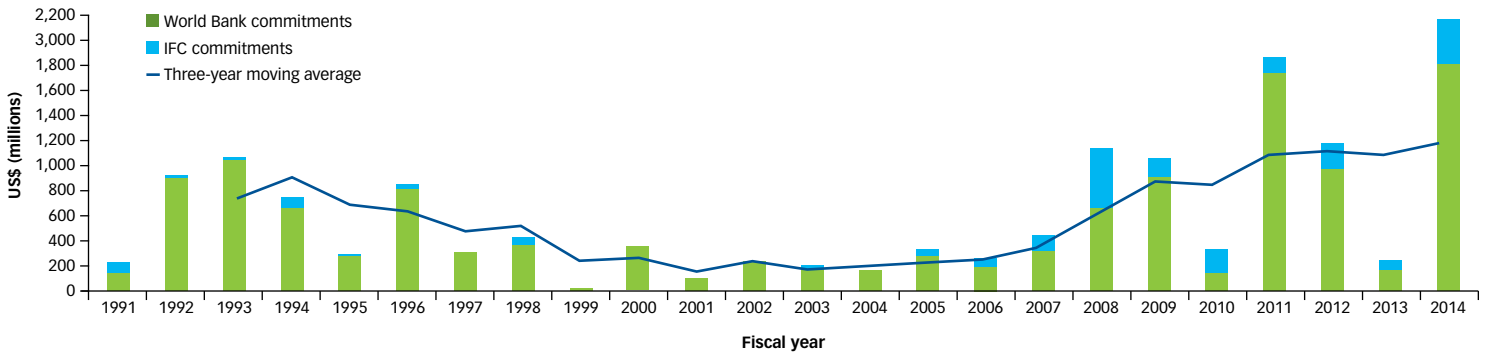
The World Bank Group supports the responsible development of hydropower projects of all sizes and types. Small-scale projects are meeting the critical energy needs of rural communities and powering their economic development. Medium- to large-scale hydropower projects power schools, factories and clinics, and deliver electricity to the growing urban population who previously lived without reliable electricity. More than half of the projects supported by the World Bank Group are run-of-river projects that do not involve the construction of large dams. Around half of the hydropower plants supported by the World Bank Group are smaller than 30 MW in capacity (figure 3).

The World Bank Group helps countries address the regional dimensions of hydropower. When a hydropower facility is built on a river that crosses international boundaries the countries affected must cooperate to optimize the facility's design and make it sustainable. The Rusumo Falls hydropower project offers a good example of how regional cooperation can lead to regional benefits—new and much needed electricity for Burundi, Rwanda, and Tanzania. In this project the World Bank played an important role in brokering an

[1] The International Bank for Reconstruction and Development and the International Development Association make up the World Bank. In addition to IBRD and IDA, the World Bank Group includes the International Finance Corporation (IFC), the Multilateral Investment Guarantee Agency (MIGA), and the International Centre for Settlement of Investment Disputes (ICSID).

"More than half of the hydropower projects supported by the World Bank Group are run-of-river or small projects that do not involve the construction of large dams. Around half … are smaller than 30 MW in capacity."

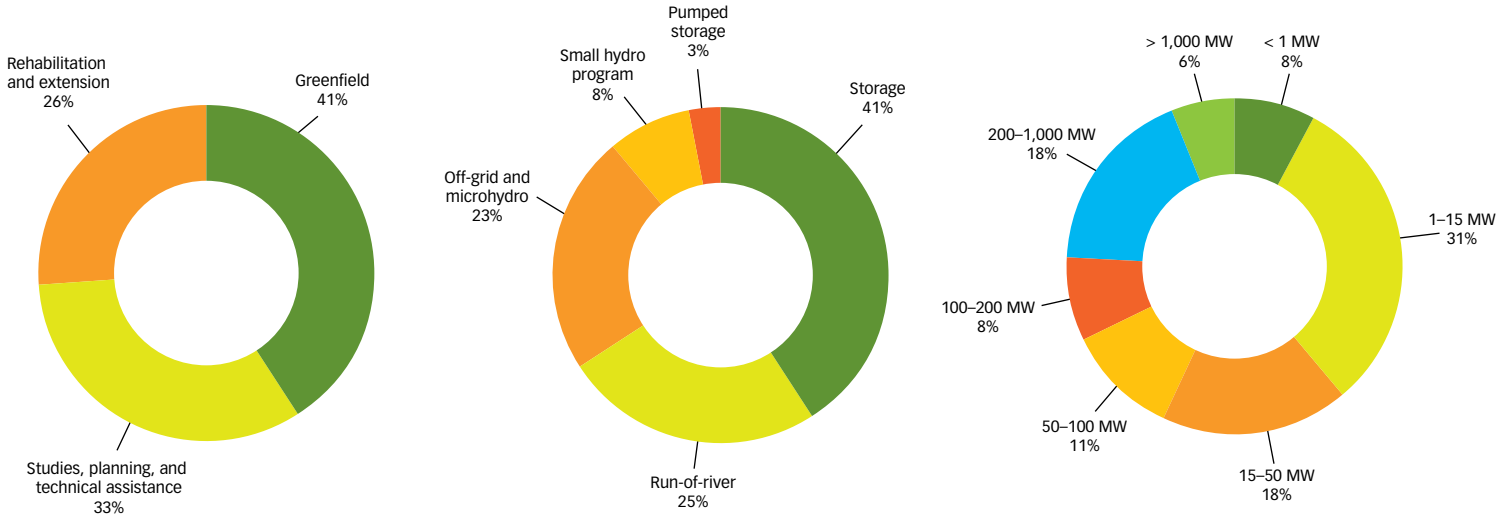
Figure 2. World Bank Group lending for hydropower development, fiscal years 1991–2014



Source: World Bank.

Note: Lending volumes represent funding for hydropower components in the year of approval. Volume of lending does not necessarily reflect the numbers of projects supported, since it is heavily influenced by the relative cost of projects and the proportion of total project financing that contributed by the World Bank Group.

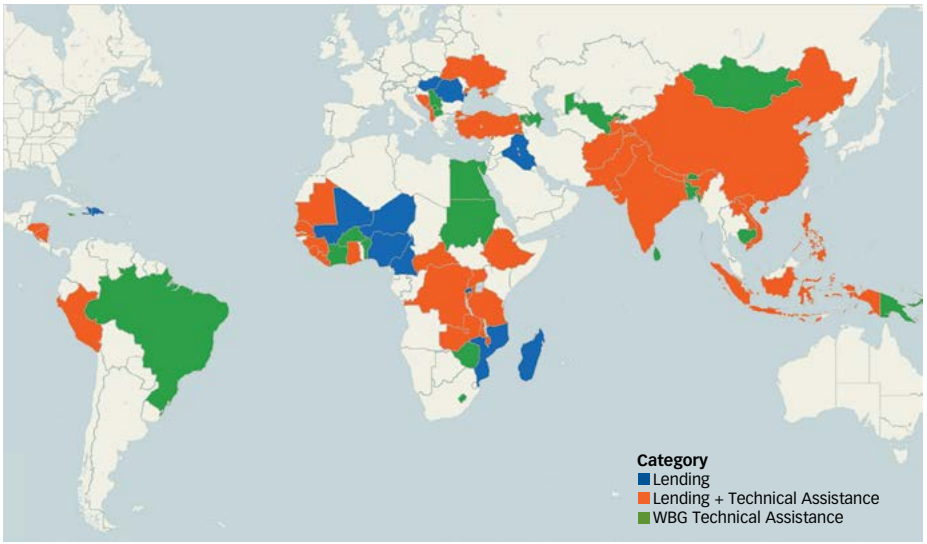
Figure 3. Focus, type, and size of hydropower plants supported by the World Bank Group, 2002–14



Source: World Bank.

Note: Figures in center chart are for greenfield and rehabilitation projects only.

Figure 4. Countries benefiting from World Bank Group support for hydropower, 2002–14



Source: World Bank.

"A hydropower facility can have important regional benefits by feeding energy into a regional power pool. In some instances, it is the ability to sell power regionally that makes a hydropower project 'bankable.'"

approach that ensured that each country benefited fairly from the project. Whether or not it lies on a shared river, a hydropower facility can have important regional benefits by feeding energy into a regional power pool. In some instances, such as in Lao PDR, it is the ability to sell power regionally that makes a hydropower project "bankable."

A key upstream challenge for many of the World Bank Group's clients is how to manage their hydropower sector as a whole, including prioritization of potential projects based on benefits and risks. Selecting and sequencing projects with reference to the broad development picture is part of the support that the World Bank Group provides to governments and regional power pools. In addition to energy needs, the process takes into account other uses of water, notably water supply for households, industry, and agriculture, navigation, fisheries, and environmental services.

Planning often requires a river-basin perspective and a long-term outlook, particularly given the role that climate change will play in increasing the variability of water available for energy as well as the need for water storage.

An important element in this broader perspective may be the need to look at the combined impacts and opportunities of multiple projects. Cumulative impact assessments are an important tool for developing this understanding. Such broader perspectives help countries do the right projects.

While ideally each country would follow the systematic approach described above, many countries do not have the resources to do such comprehensive planning, and when assessments and plans are financed by third parties, they may have limited capacity to absorb and prioritize the wide range of data and perspectives that have been provided. Further, many developing countries face urgent development needs. Wishing to meet those needs as quickly as possible, they may end up trading off potentially bigger long-term benefits against short-term demands. For these reasons, the World Bank Group also works with countries to develop their planning capacity and governance systems, while accepting that doing so is a long-term process.

Effective hydropower governance requires institutions that engage multiple parts of government, such as energy, water, environment, health, labor, agriculture, and local government. It also requires clear regulations and standards (including for social and environmental issues); coherent approaches to project finance, royalty regimes, and benefit sharing; and strong capacity for monitoring and enforcement. The World Bank Group assists clients in several of these areas, including water resource management and technical assistance programs focused on hydropower governance.

Over the last decade, the World Bank Group has provided technical assistance for hydropower development in 50 countries, demonstrating that its contribution is much broader than project finance (figure 4). An example is the World Bank Group's support for the Indian state of Himachal Pradesh, which has included a development policy loan triggered by lending for the Nathpa Jhakri and Rampur hydropower projects. The development policy loan includes actions aimed at building the state's capacity to do integrated planning for

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hydropower at the river-basin level. It led to a state law that returns 1 percent of hydropower revenues to local communities.

The public and private sectors both have important roles to play in hydropower development. By combining the private sector investment and advisory work of IFC with the public sector focus of the World Bank, the World Bank Group can help countries across the investment and policy landscape. In Nepal, for example, the World Bank Group is working on a joint 3,000 MW program that spans the private and public sectors.

The World Bank Group can help governments develop their hydropower potential in an optimal way. Hydropower projects are complex, with significant financial, technical, social, and environmental risks. Doing such projects right requires extensive feasibility work, detailed environmental and social assessment, a well-designed contractual and financing package, mechanisms that share benefits with the local community, and a rigorous approach to implementation. Developing countries often lack the resources and capacity to do this preparatory work adequately, to negotiate with developers or contractors from a position of strength, and to supervise implementation effectively. Other sources of investment may not always place a high priority on long-term sustainability, which can result in additional expenses, less-reliable power generation, unmitigated social and environmental impacts, and lower economic returns.

Based on decades of experience, as well as constant learning from successes and mistakes, the World Bank Group can help countries and companies prepare and implement hydropower projects in the most sustainable way, helping them make the most of their scarce natural hydropower resources. Hydropower needs to be sustainable on at least three dimensions:

- Physical sustainability, which is driven by design, construction, operation, and maintenance of the hydropower plant and related physical assets
- Financial sustainability, which relates to the realism of planning and cost estimation, the terms and tenor of the financing package, delays in the commencement of operations, and financial returns once operations have begun
- Social and environmental sustainability, which relates to the quality and comprehensiveness of impact assessments, the design of mitigation and compensation programs, and the systematic implementation and monitoring of these programs.

The World Bank Group is committed to continued analytic work and partnerships aimed at improving the practice of sustainable hydropower over time. Over the last decade a number of nongovernmental organizations in the environmental field, including WWF and The Nature Conservancy, have reached out to the World Bank Group to improve the way that hydropower is developed globally.

Such constructive dialog has helped the World Bank Group to reflect on its own experience and practices and to consider how various stakeholders can contribute to more sustainable practices globally. The private sector, governments, NGOs, and multilateral organizations (including the World Bank Group) came together to define the Hydropower Sustainability Assessment Protocol, which provides a useful and comprehensive framework for hydropower developers to monitor and benchmark the performance of their projects. The World Bank Group will continue to engage with the forum that governs the Protocol to encourage its use and improve the tool over time.

Even though the World Bank Group accounts for only about 2 percent of worldwide investments in hydropower, some countries—especially the poorest ones—rely heavily on concessional funding and its leveraging effect. The World Bank typically acts as a "convener," bringing other financiers to the table. In fact, over the last five years, the World Bank Group has only had to cover around half of the costs of the projects that it finances (55 percent), with the balance coming from other players, such as host country governments (19 percent), the private sector (15 percent) and other development banks (10 percent) (figure 5). In the case of Nam Theun 2 in Lao PDR (box 1), the World Bank Group contributed less than 2 percent of project financing, but through careful project structuring and guarantees, and by working with partners, the full project costs of $1.35 billion were met.

The World Bank Group supports only hydropower projects of demonstrated economic viability. For all projects the Group carefully assesses the macroeconomic and fiscal effects and risks of its investments on the national economy of the country. Because the World Bank Group learns from its experiences, the costs estimated at the time a decision is made to go forward with a project have been relatively close to actual costs in most cases, with some coming

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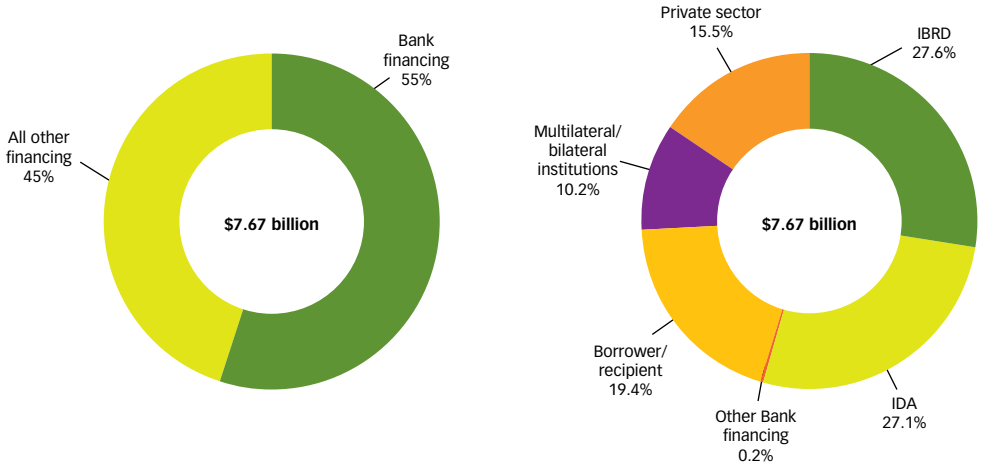
Figure 5. Financing for World Bank projects that support hydropower, 2010–14



Source: World Bank.

Note: IBRD = International Bank for Reconstruction and Development; IDA = International Development Association. IBRD and IDA make up the World Bank. Financing is for all components of the projects and not just the hydropower components.

Box 1. Nam Theun 2—Lao PDR

The 1,080 MW Nam Theun 2 (NT2) project generates 1,000 MW for export and the remainder for the local grid. Because NT2 had significant social and environmental impacts, measures were put in place to mitigate these impacts and to provide benefits at multiple levels.

- At the **national level**, the project provides revenue, electricity, and growth. Through export sales, NT2 will yield about $2 billion in government revenues over the 25-year concession period, with that revenue to be used by the government to reduce poverty and protect the environment. Electricity generation targets have been exceeded in every year of commercial operations to date. For example, in 2013 NT2 exceeded its export generation target by 10 percent and its domestic generation target by 26 percent. As a result NT2 has also been generating higher-than-expected revenue for the government. Finally, NT2 has had a significant impact on broader economic growth, adding 3 percent to GDP growth in the year that power production started.
- At the **local level**, NT2 provided resettlers with high-quality housing, electricity, and improved water sources that they did not have before, as well as community infrastructure such as schools, health centers, and roads. A comprehensive livelihood support program was also put in place. As a result, school enrollment among 5–9 year olds has jumped from 31 percent to 90 percent, and access to improved sanitation is now at 93 percent, compared with 32 percent before the project. A 2013 household survey suggests that 97 percent of households have met the household income target. The focus is now on transferring program components to local communities and ensuring the sustainability of project benefits.
- At the **regional level**, the export of energy to Thailand (5,636 GWh a year were planned; more than 6,000 GWh are actually being delivered) provides about 4 percent of Thailand's energy consumption, reducing its dependence on fossil fuels and its average cost of power.
- At the **global level**, NT2 will help avoid greenhouse gas emissions equivalent to about 45 million metric tons of CO_2 over its lifetime, after accounting for reservoir emissions.

Over a similar time frame, the World Bank Group has also supported a significant government rural electrification program (including some off-grid small hydro), which raised national access rates to 78 percent in 2011 from 46 percent in 2000. Lao PDR is an example of how big and small hydropower can play complementary roles.

Source: World Bank.

"On average … actual costs of investment have been only 1 percent higher than original cost estimates."

in below estimated costs. On average, across the eight projects that have been completed in the last decade (table 1), actual costs of investment have been only 1 percent higher than original cost estimates. However, in small, fragile countries, controlling costs can be challenging, as exemplified by the Felou HPP project. In this case, a combination of technical and governance issues significantly increased the total cost of the project.

What has been the impact of the World Bank Group's support for hydropower?

World Bank Group support for hydropower helps manage risks and can yield local, national, regional, and global benefits

The World Bank Group's social and environmental safeguards (and performance standards) provide a strong platform for managing the social and environmental risks associated with hydropower. The effective implementation of these safeguards is thus a core focus of the Group's approach.

The multiple benefits of hydropower, accompanied by the World Bank Group's unique blend of support, create opportunities for local communities, advance national and regional power security, reduce global emissions of greenhouse gases, and improve practices for sustainable hydropower. With the right planning and management, a single project can deliver benefits at multiple levels (see, for example, box 1).

Many new projects supported by the World Bank Group have increased the reliability of power supply for consumers. With its unique ability to start and stop power production within seconds, hydropower can play a vital role in balancing and controlling a country's power system. Developing countries often seek to develop hydropower because they have an urgent need to increase that control. The Bujagali project in Uganda played such a role (box 2) by bringing an end to daily load shedding during peak demand. The reliability and availability of Uganda's power supply improved because of Bujagali, leading to increased commercial and industrial activity. A second example is the ongoing Ukraine Rehabilitation project, which addresses the acute shortage of regulating capacity in the Ukraine power grid. Increasing hydropower capacity and the production of peaking power will spur development of a functioning electricity market, helping to meet one of the key requirements for technical harmonization with the electricity market of the European Union and increasing interconnection with the EU power grid. A third example consists of the recent Nathpa Jhakri (1,500 MW) and Rampur (412 MW) projects in Himachal Pradesh, which have enabled India's northern electricity grid to deliver power at the correct frequency, thus avoiding the risk of power cuts (box 3).

Most of the hydropower projects supported by the World Bank Group lower the average cost of power generation in the country. In all projects, hydropower has been selected as the least-cost alternative available. For that reason, it ultimately contributes to lowering national energy costs—quite substantially in some cases (table 2). As an example, the Dasu project in Pakistan is expected to reduce the average power production cost for the energy utility by 16 percent,

Table 1. Estimated cost compared to actual project cost for recently commissioned World Bank Group projects

Project	Estimated cost ($million)	Actual cost ($million)	Percentage variation
Yixing Pumped Storage project	583	516	–12
Nam Theun 2 HPP	1,450	1,308	–10
Bujagali HPP	798	900	13
Rampur HEP	670	697	4
Cuijiaying Multipurpose project	211	254.2	20
Naji and Xiniu Multipurpose projects	250	219	–12
Hubei HPPs (6 projects)	259	287	10
Felou HPP	100	176	76
Total 8 projects	4,321	4,357	1

Source: World Bank.

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Box 2. Bujagali Hydropower Plant, Uganda

Bujagali, a 250 MW run-of-river hydropower plant, was commissioned in 2012. Currently the largest independent power producer in Sub-Saharan Africa, it doubled Uganda's available generation capacity when it came online. The commissioning of BHPP also reduced Uganda's dependence on thermal generation based on expensive liquid fuels and helped eliminate subsidies to the energy sector, saving the government $120 million in 2012. The average cost of electricity generation was lowered by $0.05/kWh. Businesses also saw significant benefits from reduced dependence on self-generation—which, while necessary during power outages, is five to six times the cost of grid electricity. Additionally, the project has resulted in emission reductions of 904,000 metric tons CO_2 equivalent per year.

As Bujagali transformed the previous power shortage into a power surplus, Uganda was able to begin expanding access to electricity among the populace, which increased from 5 percent before the project to the current 14 percent. The success of BHPP has stimulated additional private investment in the sector, and more investors are showing interest in small hydropower producers to support the growing demand for electricity in Uganda.

A mix of World Bank Group financing and guarantees made it possible for the private sector to participate in BHPP. The support provided by the International Development Association (the concessional financing arm of the World Bank) made up just 18 percent of the project's total debt financing but catalyzed large amounts of cofinancing. Bujagali Energy Limited, a public–private consortium, will build, own, and operate the plant for 30 years before transferring it to the government of Uganda.

A variety of mitigation and compensation measures were put in place for households affected by the project, ranging from replacement land or housing, in-kind compensation for specific losses, cash compensation (including allowances for disturbance), and public services such as health and education facilities, roads, water supply, and electrification.

Source: World Bank.

Table 2. Production cost of power generated by hydropower projects supported by the World Bank Group compared with average national cost of generation

Project	Levelized production cost of power generated by project (US$/kWh)	Average cost of generation in country (US$/kWh)
Felou (Senegal, Mali, Mauritania)	0.070	0.24-0.35
Dasu (Pakistan)	0.03-0.04	0.12
Bujagali (Uganda)	0.060	0.25
Tarbela IV Extension (Pakistan)	0.025	0.12
Nam Theun 2 (Lao PDR/Thailand)	0.027	0.057 (Thailand)
Rampur (India)	0.054	0.073

Source: World Bank.

from $0.12 to $0.10 per kilowatt-hour. Least-cost alternative power sources ease the financial burden on the country's taxpayers, who so often have had to bail out government utilities when they struggle to recover costs from their customers.

By injecting a substantial amount of new energy into the power grid, hydropower projects make it possible to extend access to additional households. The Bank-financed installation of more than 17 GW of new or restored hydropower since 2002 is expected to provide access to approximately 8.4 million[2] people, 70 percent of them in the least-developed countries. When the World Bank Group supports hydropower, that support is combined with support for expansion of transmission and distribution networks and for energy efficiency. This was the case for the Bujagali Hydropower project profiled in box 2.

World Bank Group support for hydropower can also stimulate new types of investments. For example, following the adoption of new energy regulations in India, IFC helped finance the first merchant

[2] This estimate is based on the methodology developed in Live Wire 2014/6, "Measuring the Results of World Bank Lending in the Energy Sector," by Sudeshna Ghosh Banerjee, Ruchi Soni, and Elisa Portale.

"The hydropower projects financed by the World Bank Group since 2002 are expected to provide access to 8.4 million people and, over the lifetime of the projects, to avoid nearly 1.1 billion metric tons of greenhouse gas emissions."

Box 3. Rampur HEP, Himachal Pradesh, India

The Rampur Hydropower project is a 412 MW run-of-river scheme using water that exits the tailrace of the Nathpa Jhakri Hydroelectric Plant upstream. Commissioned in 2014, Rampur provides clean energy to India's northern electricity grid and contributes to the alleviation of many challenges in the Indian power sector, including low levels of connectivity and insufficient supply. In tandem with Nathpa Jhakri, which was also financed by the World Bank, Rampur provides frequency control services to the grid, contributing to enhanced stability and reliability of the power system.

With high standards of contract management, dispute resolution, and environmental remediation of muck disposal sites, the project will serve as an example for future hydropower development in India. Its community development components have been replicated by the State of Himachal Pradesh in the form of a policy on local area development funds.

The project did not require construction of a dam or inundation of any land; however, 29 families were relocated because of land diversion. To address these impacts, the project budgeted $6.5 million for resettlement and compensation and an additional $6.2 million for community development. Moreover, all affected families will receive 1,000 kWh of free electricity per month, and local residents of all affected villages will share in the benefits of the project by means of an annuity payment funded by revenue derived from 1 percent of the power generation.

An impact evaluation will be carried out at the end of the project, but mid-term results showed significant improvements in the incomes and housing situation of affected families compared with the baseline and control groups.

Source: World Bank.

hydropower plant,[3] the 192 MW Allain Duhangan run-of-river project. The project, which began commercial operations in 2010, addressed a significant power shortage in northern India, while demonstrating a new approach to electricity generation and sales.

Support for hydropower is mitigating climate change by reducing reliance on fossil fuels. The new and rehabilitated generation capacity that will be provided by the projects that the World Bank Group approved between 2002 and 2014 will avoid approximately 1.1 billion metric tons of cumulative greenhouse gas emissions over the economic life of the projects (20–50 years), comparable to the emissions from the fossil fuels burned in all of Japan in 2010 or nearly twice the emissions of Sub-Saharan Africa in the same year.[4] The actual savings will likely be much higher, given that hydropower plants last far longer than their defined economic life. The emissions avoided by displacing or avoiding generation from power stations using fossil fuels (including coal and crude oil), as most of the World Bank Group's hydropower projects have done, are equivalent to shutting down 6 GW of brand new coal-fired plants for their entire 40-year life. For example, the Tarbela IV Extension project in Pakistan will avoid emission of 41 million metric tons CO_2 equivalent over its economic life span and will reduce the country's total emissions by about 1 percent, all by adding an additional powerhouse to an existing dam. Cumulative project emissions for the portfolio reviewed are estimated at 90.5 million metric tons CO_2 equivalent, comprising reservoir emissions of 87 million tons CO_2 equivalent and construction emissions of 3.5 million tons CO_2 equivalent.

In addition to investments that deliver reliable power to national grids, the World Bank Group supports rural electrification projects, including through new and rehabilitated micro-hydropower. In the last 12 years, 15 World Bank–supported projects delivered an additional 33 MW and direct access to electricity in rural areas. In Nepal, for example, the World Bank is helping the government to install more than 1,000 micro-hydro plants in 52 districts, such as the 51 kW Ruma Khola plant, which supplies electricity to 700 households. The Bank's financial support for small-scale hydropower development in Turkey demonstrated that long-term financing for renewable energy projects was viable and led national financing institutions to match their loan conditions to support such investments in the future.

The World Bank Group's hydropower investments often support the adoption of sustainable hydropower policy frameworks. In Ukraine the Hydropower Rehabilitation project included support for the country's power regulator, which led to a new electricity market law that took effect in January 2014. World Bank and IFC support in Lao PDR has led to a new national policy on sustainability of the hydropower sector. The Rampur Hydropower project (box 3) led to

[3] A merchant hydropower plant is a privately financed independent power producer without a long-term power purchase agreement. It sells electricity to a variety of customers based on the current market.

[4] These are calculated net of any reservoir or construction emissions, where applicable.

"Most of the hydropower projects supported by the World Bank Group lower the average cost of power generation in the country … Moreover, with its unique ability to start and stop power production in seconds, hydropower can play a vital role in improving system reliability."

the introduction of several good practices for contract management that were promptly adopted by the state hydropower developer.

Research associated with the World Commission on Dams (WCD 2000) showed that hydropower resettlement had often further impoverished poor communities. Significant progress has been made in improving the design and implementation of resettlement programs over the last 15 years. Data now suggest that responsible implementation of hydropower projects *can* bring benefits to local communities.

The multipurpose hydropower projects supported by the World Bank Group during 2002–14 have resettled about 70,000 people. Social surveys conducted so far for these projects have shown improved livelihood for those resettled and for others affected by the projects. By following safeguards and performance standards and by forging partnerships with affected communities, governments, civil society, and the private sector, the World Bank Group has demonstrated in the projects it supports how to mitigate and compensate for the negative impact of resettlement, and, more ambitiously, how to create positive effects by treating resettlement programs as development programs. The Nam Theun 2 project described in box 1 invested about $55 million in social measures, and a recent survey shows that 87 percent of resettlers report that their lives are better than they were before resettlement. For the Rampur project (box 3), a recent survey shows the average income of affected families increased by 26 percent over the baseline in real terms, with an average reported income 41 percent higher than that of the control group. However, such progress does not change the fact that large-scale resettlement is immensely disruptive to the communities involved, and the first priority should be to avoid it wherever possible.

Between 2002 and 2014, the World Bank Group invested nearly $1.5 billion in rehabilitation or extension of 60 individual hydropower projects, increasing the life, safety, and performance of existing plants that continue to deliver cheap, clean power. As an example, the Ukraine Hydropower Rehabilitation project refurbished the oldest hydropower plant in the country, the Dnieper HPP, which was completed in 1932 before being destroyed and rebuilt twice during WWII. World Bank support will ensure that this plant will provide clean, affordable electricity for well over 100 years.

What are the World Bank Group's remaining challenges in the hydropower arena?

"Sustainable hydropower" is the big challenge

As mentioned at the outset, sustainable hydropower has three dimensions: physical, financial, and social/environmental. While a large amount of progress has been made on sustainability, particularly over the last decade, new challenges continue to emerge or become more pressing. These include:

- **Securing multiple benefits from investments in hydropower.** Energy generation, energy storage, grid regulation, water storage, interbasin transfer, irrigation, transportation, tourism, watershed protection, and local development have all been linked with hydropower projects in the past. It is unrealistic to expect every project to deliver benefits on every front, but the key is to ensure that planners and decision makers are fully aware of the range and realism of potential benefits before they decide on a particular approach. The ability to assess and harness financial benefits from related changes brought by the project (its "externalities") lies at the core of this challenge.
- **Managing cascades of projects.** Depending on how they are managed, multiple projects on a single stretch of river can present additional benefits or exacerbate negative impacts. Understanding cumulative impacts, optimizing operating regimes, and concluding contractual or governance arrangements that encourage good management of cascades is a key challenge.
- **A more sophisticated understanding of land and water interactions** will help developers size projects appropriately.

New challenges inevitably will emerge over time, and the World Bank Group remains committed to learning how to tackle them—and to helping its clients to develop truly sustainable hydropower.

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Live Wire 2014/6. "Measuring the Results of World Bank Lending in the Energy Sector," by Sudeshna Ghosh Banerjee, Ruchi Soni, and Elisa Portale.

Bibliography

EIA (Energy Information Administration, U.S. Department of Energy). 2013. *International Energy Outlook 2013.* Washington, DC.

IJHD (International Journal of Hydropower and Dams). 2013. *World Atlas and Industry Guide.* Wallington, Surrey: IJHD.

Kumar, A., T. Schei, A. Ahenkorah, R. Caceres Rodriguez, J.-M. Devernay, M. Freitas, D. Hall, Å. Killingtveit, and Z. Liu. 2011. *Hydropower.* In *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation*, edited by O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, and C. von Stechow. Cambridge and New York: Cambridge University Press.

Skinner, J., and Haas, L. J. 2014. "Watered Down? A Review of Social and Environmental Safeguards for Large Dam Projects." Natural Resource Issues 28, International Institute for Environment and Development, London.

World Bank. 2004. "Water Resources Sector Strategy: Strategic Directions for World Bank Engagement." World Bank, Washington, DC.

World Bank. 2013. "Toward a Sustainable Energy Future for All: Energy Sector Directions Paper." Board Report 79597, World Bank, Washington, DC. http://documents.worldbank.org/curated/en/2013/07/18016002/toward-sustainable-energy-future-all-directions-world-bank-group%C2%92s-energy-sector.

World Bank and IEA (International Energy Agency). 2014. *Sustainable Energy for All—Global Tracking Framework.* World Bank: Washington, DC.

WCD (World Commission on Dams). 2000. *Dams and Development: A New Framework For Decision-Making.* London: Earthspan.

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