The contribution of hydropower to modern society is significant and continues to grow, supporting economic and social development worldwide. Nevertheless, there is an enormous diversity of conditions of hydropower use and visions for the future. North America and Europe use over 80% of their hydropower potential and, on the other extreme, Africa uses 3%, with these differences reflecting respective economic development. Hydro contributes 17% of the total world electricity production, with hydropower plants in some 150 countries, and 24 of these countries depend on it for 90% of their electricity supply. The major hydrocountries are shown in Figure 1.

Hydroelectricity recently began to be in the spotlight because of two completely opposite views. On one hand, supporters quote its clean energy production characteristics, which are an attractive attribute in an emission-constrained world. On the other hand, the international antidam lobby demands that major hydro developments be stopped altogether.

**Phases of Hydro Development**

Development of hydroelectric power worldwide has progressed through three main phases since the late 19th century. These phases correlate directly with the type of projects selected for development and the resources available for implementation, such as rivers, mountains, and precipitation. Phase I can be thought of as the birth of modern power systems and comprises the time from the first development of the electric generation industry through to the late 1930s. This period was characterized by project development by largely private sector utilities and industrial companies to meet immediate demands. Financing

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**figure 1.** Major hydro producers in 2004 (data from the International Energy Agency).
was limited and projects were developed as needed, often for specific industrial ventures in the developing world. The configuration and capacity of the projects considered were driven by economic and technical factors, usually leading to modest-scale projects that could be financed from the resources of the relatively small utilities in existence at that time.

Phase II was ushered in by the recession of the 1930s and the rapid economic growth and industrialization following World War II. The recession first led some governments to intervene to develop some large hydropower projects, like the Tennessee Valley Authority and the Bonneville Power Administration in the United States, or create state agencies to drive investment in power supply, as in Canada and several other countries around the world. Further on, industrialization expanded energy use significantly as development spread internationally. The growth rate promoted by economic planners exceeded the capability of the nascent private utilities to finance the required generation expansion. Accordingly, many governments took further direct roles in the power sector through the formation and/or expansion of publicly owned utilities. In the developing world, the major financing needs in this period were supported by the multilateral financing agencies. During the 1960s and 1970s, utilities embarked on programs of building large projects supported by government financing resources in an effort to keep pace with an increasing demand to foster development in emerging economies. Projects were designed to meet several needs, including water supply, flood control, and irrigation as well as power generation, and were intended to be national development “engines,” in addition to the simple purpose of generation.

In the present Phase III that has evolved during the last 15 years, the world has in many ways returned to the development model used during the emerging years of the power industry. This can be characterized by market-driven investments, as the economies move away from the centralized, nationalized structures that were artifacts of the “mega” project phase in the 1960s and 1970s. One of the most important elements driving this transition is the realization, mainly in the developing world, that foreign direct investment can be an important source of financing the large capital requirements of power-sector expansion. Multilateral financing has ensured that many nations have matured politically and commercially so that large-scale foreign investment is viable. This phase has several variants, and the extent to which each country has moved down the road of market-driven investment
governs investment strategy adopted by private power developers. Today, energy sales from independent power projects use various vehicles ranging from direct power purchase agreements with a utility at the outset of privatization to a sophisticated power pool or merchant market in the more developed markets.

The Hydro Challenges
A significant change has occurred in the professional orientation and background of hydropower development proponents, particularly during the last decade. It is well known that hydroengineering has reached a level of sophistication and maturity such that, given previous experience in the development of hydro, most technical difficulties of hydro implementation are well understood and can be solved (at a price). The main difficulties pertain to accurately forecasting and quantifying the risks and associated costs of each individual project. Numerous factors control whether, and to what extent, private funding is available for the support of hydropower project development throughout the world. One of the difficulties with attracting private investment and finance to hydropower projects is the need for a higher return on equity than was traditionally sought by utilities and the multilateral agencies.

Much of the criticism of hydropower centers on the environmental effects of large reservoirs, and in particular the problems of resettlement. The general guideline has been that the smaller the reservoir, the more likely the project is to be environmentally friendly. Developers and financial institutions recognize the importance of this aspect of project development, and environmental and resettlement issues are always in the list of factors when projects are subject to preliminary assessment of viability.

In This Issue
We invite you to read this special issue of thought-provoking articles to appreciate the discussions taking place on hydro progress in several regions of the world: South America, where hydro development is very active; the United States and Canada, where the greatest portion of the hydro potential has already been explored; China, a fast-growing market with significant hydro resources; and Africa, with still a large potential unexplored. Each article will cover the state of development of hydroelectricity in its region. Potential for growth, specific projects, environmental constraints, and economics are a few of the issues that will be covered with articles encompassing diverse flavors around the globe.

The South American overview is provided by Hugh Rudnick, Luiz A. Barroso, Sebastian Mocarquer, and Bernardo Bezerra. They emphasize...
that the primary challenge faced by South American countries is to ensure sufficient capacity and investment in electricity infrastructure to serve reliably their growing economies, currently faced with shortages and high prices. Within those conditions, the development of vast unexploited hydroelectric resources, particularly in Brazil, is at the center of attention, where its renewable character is being confronted with its environmental impact.

Canada and the United States are world leaders in hydropower. Among the first countries to develop hydropower facilities in the 1880s, they are today in the top-four producing countries. Linda Church Ciocci provides the U.S. vision, indicating that hydropower is the largest renewable-energy resource in the United States, accounting for more than three-quarters of all existing renewable-energy capacity in the country. She emphasizes opportunities for growth in every part of the U.S. hydropower sector, even with existing conventional hydropower dams, where new technologies that improve efficiency could, in the next 20 years, add up to approximately 2,300 MW—the equivalent of two large-sized coal or nuclear power plants.

Regarding Canada, Pierre Fortin indicates that, from the late 1880s onward, hydropower has been developed to the extent that, like the national railway, it helped to define Canada, opening up remote regions, attracting industries, and stimulating economic growth. Canada generates now close to two-thirds of its electricity with water. The role that hydropower can play in reducing greenhouse gas emissions is emphasized, by powering cars, trains, and subways and by replacing the burning of coal and natural gas for electricity generation.

The China overview is provided by Shuti Fu and Jin Zhong, who describe the energy shortages that have occurred in the recent past, affecting the country’s economic development and its social life. This reflects on the need to install more than 100 GW annually in 2006 and 2007, mostly from coal-fired thermal power plants that are the main sources of pollution in the country. This has made it evident that the future lies in the exploitation of more hydro power, more nuclear power, and other clean and sustainable energy resources, with a potential hydropower capacity of 676 GW. Flood control and environmental and agricultural benefits are to be balanced with the need to displace significant numbers of people.

Finally, the continent in the dark, as Africa has been described because of its lack of enough electricity, is covered by Bai K. Blyden and Fenda A. Akiwumi. They indicate that Africa’s exploitable hydroelectric potential is estimated at approximately 1.4 million GWh/year, which is sufficient to supply electricity for the entire continent; but only 3% of this hydroelectric potential is available. Therefore, hydropower development is a major goal in Africa. Matters of concern in the exploitation of its hydropower potential are the poor integration of technical data with demographic, socioeconomic and environmental data, corruption, and conflict. Nevertheless, there is a declared will to work toward addressing and overcoming these obstacles in an energy-thirsty continent.