The U.S. electric utility industry is in a state of dramatic flux. As a result of utility deregulation, primarily in the northeast and west, almost 20 percent of the U.S. electricity market is open to competition, with an even greater percentage soon to be exposed as a result of newly enacted deregulation legislation passed in other states. Significant levels of utility generating assets have been sold or are currently on the block, and recent merger announcements indicate that merger activity is alive and well.

Included in all this activity are pressures on electric utility coal-fired power plants to reduce generating costs to enhance their competitive position, while at the same time responding to environmental initiatives that will increase power production costs. Tack on over 100,000 MW of planned gas-fired capacity additions soon to meet increasing levels of demand, and the obvious question becomes, “to what level will coal-fired generation be able to compete in the near-term?”

Resource Data International, Inc. (RDI) answered this question in its recently released Coal-fired Generation in Competitive Power Markets Syndicated Study. The study examines and projects the impacts of the three primary drivers behind coal-fired generation in the near future, including: 1) electric utility deregulation, 2) new environmental regulations, and 3) competitive pressure from planned installations of high efficiency combined cycle gas-fired generation. RDI expects these three issues to impact the dispatch sequence, coal volumes, coal-plant power production costs, and future viability for coal-fired generators and their suppliers throughout the 21st century.

MODELING ASSUMPTIONS

To assess the overall impacts on coal-fired generation, RDI first made several assumptions regarding the outcomes associated with electric utility deregulation, environmental compliance, and new gas-fired capacity additions by 2003 - the year modeled in the study.

THE WHOLE DAM STORY:
A Review of the China Yangtze Three Gorges Dam

By Don Challman

PART II OF A II PART SERIES

In the last issue of Energeia, Don Challman discussed the proposed benefits of building the new dam. Here he plays devil’s advocate and looks at the costs associated with such a venture.

PUBLIC COSTS

For all the benefits promised by the Three Gorges Dam, they will not be realized without some sacrifice with

(continued, page 2)
U.S. Electric Utility Coal-Fired Generation, (cont.)

These included plant-level assumptions for coal procurement and delivered coal prices, projected installations of pollution control equipment for compliance with applicable SO2 and NOx regulations and prices for SO2 and NOx allowances, and coverage and costs of new gas-fired capacity additions. The assumptions used within the modeling process included:

**Coal Sourcing:** RDI projected plant-by-plant delivered coal prices in 2003, with all above-market coal and transportation contracts eliminated and replaced, where necessary, with forecast market coal prices and transportation costs. Coal sourcing decisions were optimized on the basis of the lowest sulfur adjusted power production cost, and adjusted for derates associated with the use of subbituminous coal.

**Environmental compliance:** All coal-fired units larger than 25 MW were assessed a sulfur emission cost corresponding to the amount of SO2 emissions expected in 2003 and a forecast SO2 allowance price in 2003. RDI also included an additional variable operating and management cost for operation of flue gas desulfurization (FGD) equipment among units having announced that such installations will be operating prior to year-end 2003 and units RDI projects to install FGD by the end of 2003. RDI assessed an NOx compliance cost during the five-month ozone season (May through September) to coal units larger than 25 MW located in the eastern 22-state region affected by ozone transport. The NOx adder is based on expected NOx emissions rates and a forecast NOx allowance price in 2003. Likewise, any units projected to install NOx control equipment, like selective catalytic reduction or selective non-catalytic reduction, to comply with regional ozone transport were assessed an additional variable O&M expense to reflect the cost of operating NOx control equipment. Using roughly the same approach, all coal-fired units in Texas were assessed an NOx cost adder.

**Natural Gas Capacity Additions and Cost:** RDI’s most recent natural gas price forecast was used to derive delivered natural gas prices to gas-fired units. The model incorporated over 80,000 MW of new gas-fired capacity, roughly 60 percent of which are gas combined-cycle units. The WSCC, NPCC, ERCOT, and SERC regions are projected to receive the most significant gas combined-cycle capacity additions.

The above assumptions were input into the electricity dispatch model, IREMM (interregional electricity market model). IREMM outputs include unit operating levels for every U.S. generating unit providing electricity to the grid. Within the model, the projected level of coal-fired generation for an individual unit, or similarly the degree to which its generation is displaced by new combined-cycle gas units, is determined by its forecast power production cost, electricity demand growth in the region, and the extent of new gas capacity additions.

**IMPACTS ON COAL-FIRED GENERATION**

The result of the dispatch modeling shows that overall coal-fired generation continues to grow despite the addition of significant environmental emission costs and competition from new natural gas units. RDI forecasts total coal-fired generation to increase 7.8 percent from 1998 to 2003, while total utility generation is forecast to grow 7.2 percent during the same period. However, the projected growth in coal-fired generation is over 2 percentage points less than a scenario without the additional costs linked to environmental compliance—a difference that translates into approximately 23 million tons of coal.

The additional cost of environmental compliance, especially in the east during the summer ozone season, combined with the arrival of new gas combined-cycle units, spells risks for certain coal plants and national electric reliability council (NERC) regions. RDI projects that one-fourth of total utility coal capacity is at risk in 2003 from displacement by lower-cost generation from new gas combined-cycle units. However, the level of risk posed by these new gas unit additions ranges from minimal to severe. RDI has characterized “low” risk coal units as those with total power production costs in 2003 which exceed the total production cost of new gas combined-cycle units by $2/ MWh or less, “medium” risk coal units at a $2/ MWh to $5/ MWh cost disadvantage, and “high” risk coal units above a $5/ MWh differential. The variation in risk among coal-fired power plants across the country is portrayed in Figure 1, with the darker shades representing coal-fired units facing the greatest risk from displacement and the lighter shades indicating coal-fired units least at risk.

![Figure 1. Coal-fired capacity at risk to combined cycle gas displacement, 2003 by ner region](image-url)
Based on this approach, approximately 30,000 MW of coal-fired capacity is forecast to be at medium to high risk from displacement from new, combined-cycle gas units in 2003. Because each NERC region has a distinct flavor of coal-fired generating costs and exposure to environmental compliance and gas-capacity addition risks, the risk of displacement by new, gas combined-cycle units varies among each of the NERC regions.

A risk coal units in MAIN, ECAR and NPPC are forecast to be most affected by new gas combined-cycle capacity additions and environmental compliance costs. RDI forecasts generation from at-risk coal plants in these three regions will each decline 2 percent from 1998 to 2003. Most of the coal generation displacement is anticipated to occur during the summer ozone season when the NOX compliance adder increases power production costs; sometimes above that for gas combined-cycle units. Coal plants in the SERC region show no change in generation from at-risk coal units, while at-risk units in all other NERC regions are forecast to increase generation.

The impact for coal units in NPPC will be the most severe among the three regions. RDI projects 38 percent of the region's total coal-fired capacity will be at risk and 31 percent will be at medium to high risk from displacement by additions of gas combined-cycle units. Moreover, the planned addition of slightly over 9,000 MW of new gas units in NPPC is projected to exceed the total coal capacity at risk. Within MAIN and ECAR the risk posed by gas capacity additions is less severe. Sixteen percent and 8 percent of coal-fired capacity in MAIN and ECAR, respectively, is anticipated to be at medium to high risk, and the amount of new gas capacity additions falls short of the total coal capacity at medium to high risk, especially in ECAR.

Displacement by new combined-cycle gas units is more likely to occur among smaller, less efficient and higher-cost coal units east of the Mississippi River, especially within the summer ozone season. Displacement of generation from the higher cost coal units by gas combined-cycle units will occur more during intermediate load periods, like weekends or nights, when electricity market prices are not at their highest levels, thereby softening the impacts of displacement on coal plant profitability. The same can not be said for impacts of displacement of coal generation on upstream coal providers including coal producers and railroads. For these suppliers, a loss of coal directly translates into lost revenues and profits. With 23 million tons of coal at risk due to the costs of environmental compliance, the impacts for coal suppliers and transporters are noticeably more significant.

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U.S. Electric Utility Coal-Fired Generation, (cont.)

respect to the human and natural environment of the Yangtze River Basin. The area will be forever changed and it will be much more than the scenery. A host of issues will need to be addressed to diminish the negative impact of the dam on the human environment, ranging from changes in the patterns of land use and habitation, to resettlement of the population, to public health, to impacts on cultural relics and historical sites. Likewise, quite serious consequences will need to be addressed to lessen the dam’s impact on the natural environment (e.g., the inevitable changes in the landscape, hydrology and geology, the diversity of plant and animal life, water quality and the estuarine ecosystem).

The Whole Dam Story, (cont.)
conditions. During the dry season, the water level behind the dam will be raised to over 328 feet, and 165-200 feet in the backwater of Zhongxian County. By contrast, the steep narrow canyon walls of the Gorges rise 4000 to 5000 feet. Water levels are expected to diminish the height of the gorges by about 10 percent. The landscape and feel of the “far” and “middle distance” views will not be altered appreciably.

The impoundment will completely submerge a number of important and protected relics and cultural heritage sites below the inundation line, and partly submerge many others. Among the more important sites that will be lost are the tombs and burial sites of the dynasties inhabiting that region since ancient times, among them, the Xia, Shang, Zhou, Warring States, West Han, Jin, Southern, Northern, Tang and Song Dynasties. Places of worship, burial grounds, antiquities, everything that can be moved will be taken to higher ground and reconstructed. If they can’t be feasibly moved, the Chinese government has made detailed plans for protecting and preserving important structures and artifacts, either in situ through the selective use of dikes and foundation reinforcement, or if necessary by removing them for public display in government buildings and museums.

**FISH AND WILDLIFE**

The Yangtze River basin is teeming with over 300 species of fish, and its annual aquatic production accounts for half of the nation’s gross output, mostly endemic species of black carp, grass carp, silver carp and bighead. Environmentalists state that important fisheries will be diminished or lost, and the habitats of endangered species of mammals, birds, reptiles and fishes will be destroyed by the reservoir. Among the species protected by the nation which could be impacted: the Chinese river dolphin, white stork, Chinese tragopan, red-crowned crane, Yangtze alligator, Chinese paddlefish and Chinese sucker. Of particular concern is the fate of the Chinese river dolphin, nearly extinct with a population of only 200 individuals. The government has promised to set up nature preserves in the upper reaches and in protected sections of the middle reaches to support the river dolphin. The dam will also block the route to upstream spawning areas of migratory fish species, particularly prehistoric species of Chinese and Yangtze sturgeon.

However, the route was already blocked downstream when the Gezhouba dam became operational. Countermeasures that have been and will be pursued by China to support the fishery resource include protecting fish spawning areas in the reach below Yichang, establishing artificial breeding and stocking stations, and operating the reservoir to promote fish breeding.

The basin is also abundant in flora and vegetation: 2,787 species of vascular plants, of which 47 species have been identified as rare and endangered and protected by the nation. Five hundred fifty plant species will be impacted by the impoundment, including several rare and threatened plants, but it will not lead to the extinction of endangered species according to official statements.

**IMPACT ON WATER QUALITY, THE LAKES REGION AND ESTUARY**

Water quality of the river is already exceptionally poor with largely untreated discharges of industrial wastewater, domestic sewage, agriculture runoff, urban storm water and waste discharges from ships. The main pollutants are volatile phenols, total phosphorus, biochemical oxygen demand (BOD), coliform, total nitrogen, oils, chemical oxygen demand (COD), suspended solids, total mercury, sulfides, cyanides, hexavalent chro-
The Whole Dam Story, (cont.)
hundreds of miles to the estuary. Among the concerns are sestonimilation and scouring of the banks below the dam’s outflow, waterlogging in the lakes region and salt-water intrusion in the estuary, which could jeopardize the drinking water of Shanghai.

According to official documents, water quality in the river should not be greatly diminished and the capacity of the reservoir is sufficient to assimilate the pollutant loading. The government has moved aggressively to close some industries and to replace them with modern factories with wastewater treatment facilities. Over a dozen municipal wastewater treatment plants are also in the planning or construction stage, which offers the future prospect that discharges will at least be treated. They have also promised to take all precautions in the remediation of industrial sites and to clean-up solid waste dumps and landfills before the area is inundated in 2003. Chinese models of the scouring of downstream banks indicate that the time needed to achieve the maximum cumulative scouring of the bank is 40-50 years from Yichang to Chenglingji, 60-70 years below Chenglingji. This will be remedied somewhat by operation of the reservoir—the controlled release of water behind the dam. Attention will also begin to monitoring and reinforcing the banks, levees and protection works, and dredging harbors, navigation facilities and shallow bendways in the river.

INUNDATION AND RESETTLEMENT

Of all the concerns raised about the Three Gorges Dam, few have been more thorny or divisive than the relocation and resettlement of the population. The numbers affected by the dam are staggering: 244 square miles of land will be inundated impacting 19 counties or cities, 140 towns, 326 villages, the homes and livelihoods of 1.3 million people in Hubei and Sichuan Provinces. Seventy-one thousand acres of agricultural land will be taken out of production, about 60 percent dryland, 25 percent paddy field, and the balance citrus orchards. As a result, 40 percent of the population to be moved are subsistence farmers, fishers and peasants living in remote villages who rely on the Yangzi for its abundant fishery resource and the fertile soil deposited on the bottomland. The remaining sixty percent are urban residents of the many cities and towns dotting the banks of the Yangtze from Chongqing to Yichang. These people labor in the mineral industries: gold, silver, iron, uranium, coal, phosphorus, natural gas and rock salt. Others are employed in the manufacture of local products of tung oil, raw lacquer, goat’s skin, raw silk and rare Chinese herbs and medicines.

China’s leaders have promised that resettlement planning and implementation will command the highest priority, and all diligence and care will be exercised in carrying out the task. The government will spend a substantial sum to rebuild housing, roads, harbors, bridges, utilities and treatment works; provide alternative land for farming; retrain the workforce for jobs in modern re-tooled factories; and cover resettlement costs and other incentives for relocatees. Whole cities of aging, dark, soot-covered concrete structures at river’s edge—tenement houses, schools, businesses, factories, shanties and hovels—will be dynamited, built dozed, remediated and hauled away to clear future shipping lanes. Where suitable land is available, the plan is to rebuild eight of the larger cities and over half of the 140 towns nearby their present location—a few hundred yards above the new high water line. In areas where land is available, the farmers will begin new lands for livestock and crop production in a land-for-land swap.

Critics of the dam insist that the resettlement program is floundering from poor planning, mismanagement, official corruption, inadequate compensation, a shortage of farmland, and a lack of jobs for the relocatees. Moreover, the government has been sharply criticized by human rights organizations about the suppression of dissenting viewpoints about the dam and the potential forced resettlement of the population. Because land is scarce, four or five major cities and as many as 65 small towns impacted by the dam will be relocated to more distant places and the relocatees will be moved together with the cities or towns they have been living in. Moreover, there is not enough farmland to compensate for all the losses of area farmers, and those that have received new allotments have been pushed onto marginal erosive lands on steep slopes above the river. Others will be forced to leave ancestral lands, separate from extended families, and prepare for new factory jobs and livelihoods in the cities. Critics have also argued that insufficient attention has been given to health services and sanitary facilities. Health services, drinking water supplies and sanitation are poor. There is a high incidence of rheumatic fever, hepatitis B, pneumonia, measles and diarrhea among the population. The most serious threats are the establishment of schistosomiasis, malaria and other parasitic diseases in the reservoir area.

The detractors of the dam need only point to the record of past Chinese relocation efforts: as many as 10.2 million people have been resettled because of the construction of dams and reservoirs in China. Close to a million people were relocated in three of the larger projects—the Samnanzia, Danjiangkou and Xin’anjiang Dams. ‘In all three cases, resettlement was rushed and accompanied by intimidation and sometimes violence.’ Moreover, there is insufficient proof that the dams have actually lead to any appreciable improvement in economic development or living standards of the inhabitants. According to Chinese reports, nearly 70 percent of the 10.2 million relocatees still remain in extreme poverty – some more than a decade after being displaced. Nevertheless, Chinese officials maintain that despite the admitted difficulties in relocating so many people, for every one person displaced by the project in the upper reaches, six persons will benefit directly from improved flood control in the lower reaches and lakes regions; and indirectly, 20 persons will benefit counting the larger population of the estuary at Shanghai. In addition, for every one acre of arable farmland that will be inundated by the impoundment, 60 acres will be safeguarded from flooding in the lower reaches.

CONCLUSION

Well, there you have it: “The Whole Dam Story” - the arguments for and against constructing the Three Gorges Dam. This dam, like all large dams and other public infrastructure, is a story about trade-offs. In trade for the benefits of safeguarding the downstream populace from the ravishes of flood waters, humankind will uproot and inflict hardships on people who find themselves in the way of progress. In trade for inexpensive, clean power and better navigation, and all the promises of improved health, education and living conditions that come with economic prosperity, humankind will irretrievably alter the landscape and put at jeopardy the biodiversity of a river basin (and by association, the planet). The best we can hope for is that the benefits are for the many and the hardships for the few. If you still can’t make up your mind about this project, Father Time and Mother Nature will eventually pass judgment.

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This symposium will focus on the scientific study and process engineering of deactivating catalysts, as well as their regeneration.

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