MARCH/APRIL 2013 • VOL 29 NO 02
MALAYSIA: RM39 • ELSEWHERE: € 17.60

asian WATER

ASIA'S LEADING WATER & WASTEWATER, PUMPS, VALVES AND FILTRATION TECHNOLOGY MAGAZINE

Kuala Lumpur's experiments with water

Worldwide advances in water reuse - Part 1

Interview: Datuk Abdul Kadir, Indah Water Konsortium

Interview: Robin Gledhill, Blue-White Industries

Managing the Electricity-Water Nexus in China and India

www.asianwater.com.my

ASIAN WATER
MARCH/APRIL 2013

Managing the Electricity-Water Nexus in China and India

On a typical day, Chinese and Indian power plants withdraw more than 480 billion litres of fresh water—nearly twice the amount that passes over Niagara Falls in a 24-hour period. This massive use of water presents a critical constraint often overlooked in electricity and energy decision-making.

By Benjamin K Sovacool, Sara Imperiale, Brian Thomson, Alex Gilbert, Jay Eidsness, AjithRao

Much has been written about the meteoric rise of the Chinese and Indian economies, and it is well documented that this phenomenal growth has coincided with a massive expansion of thermoelectric power plants—power plants that either burn their fuels to generate electricity or that fission atoms in nuclear reactors. The process of thermoelectric power generation utilises prodigious amounts of water, primarily for cooling purposes. Most of the existing as well as the planned thermoelectric generators are heavily dependent on the assumption that water resources remain abundant, clean, and readily available.

For instance, on a typical day, Chinese and Indian power plants withdraw more than 480 billion liters of freshwater—nearly twice the amount that passes over Niagara Falls in a 24-hour period. This massive use of water presents a critical constraint often overlooked in electricity and energy decision-making. Addressing the challenges that the reliance on water poses to electricity generation requires us to think more broadly about integrated resource planning, reliability challenges, and resource selection.

China's rapid growth is staggering. It is currently the world's most populous country, the biggest emitter of greenhouse gases, the fifth largest producer of oil, the seventh largest producer of natural gas, and the largest miner of coal. Over the past ten years, 70 million new jobs were created and, since 1984, more than 600 million Chinese citizens—nearly 10 % of the global population—have been lifted out of poverty. The country now leads the world in markets for automobiles, steel, cement, glass, housing, power plants, renewable energy, highways, rail systems, and airports. Analysts expect the Chinese GDP to grow from US$6 trillion in 2010 to US$9 trillion by 2015. If this rapid growth continues, China will overtake the United States as the world's largest economy sometime in the 2020s. Rapid economic growth has led to a corresponding increase in energy use. Between 1990 and 2008, energy use in China grew a staggering 146%. In order to meet these increasing energy demands, the Chinese government has been building thermoelectric power plants at a frenetic pace, and increase capacity at existing facilities. It is said that a new coal power plant comes online in China every week.

Similarly, India's economic growth and large population make it a major energy consumer. With the world's second largest population (at 1.1 billion according to the last census) and seventh largest landmass, India has the tenth largest economy in the world, or third largest when adjusted for purchasing power parity. India has the world's sixth largest electricity sector, and is the third largest energy consumer and fifth largest emitter of greenhouse gases. With a young population whose median age is only 26 years old, analysts expect India to pass China as the world's most populated nation in 2025.

In this article, we argue that the ability of India and China to manage its respective electricity-water nexus will have profound implications on each country's economic growth, social stability, environmental quality, and energy security.

THE ELECTRICITY-WATER NEXUS IN CHINA

The Chinese urban population grew from 300 million in 1990 to 550 million in 2005, with a corresponding increase in demand for water. After the United States, China is the second largest irrigator by volume, which has led to reductions in both surface and groundwater resources surrounding cities. Today, an estimated 70% of China's rivers and lakes are significantly contaminated, more than half of China's cities report polluted groundwater, and acid rain affects more than 30% of China's land area. About 30% of river water is too polluted to safely use for agricultural, industrial, and electrical purposes. Two-thirds of China's 660 largest cities suffer from water shortages, with 110 facing "severe" shortages. In addition, water pollution sickens at least 190 million people and causes 60,000 premature deaths each year. Because of such extensive pollution, China's per capita availability of drinkable water sources is about a quarter of the world average.

A 2012 study led by the Chinese Academy of Sciences, Chinese Academy of Agricultural Sciences, and a team of international researchers concluded that "China faces its own 'perfect storm' as rapid economic transition drives increasing per capita demand for water, food, and energy with farreaching environmental consequences." This echoed the findings of a 2009 review sponsored by the Chinese government. That assessment examined the country's 646 counties and found that "heavy water and soil losses" were common. The Yangtze River and Yellow River valleys, home to one-third of the Chinese population of nearly 1.4 billion people, had 82% of the worst affected counties.

The tension between providing water for drinking, manufacturing, and irrigation is especially acute in Northern

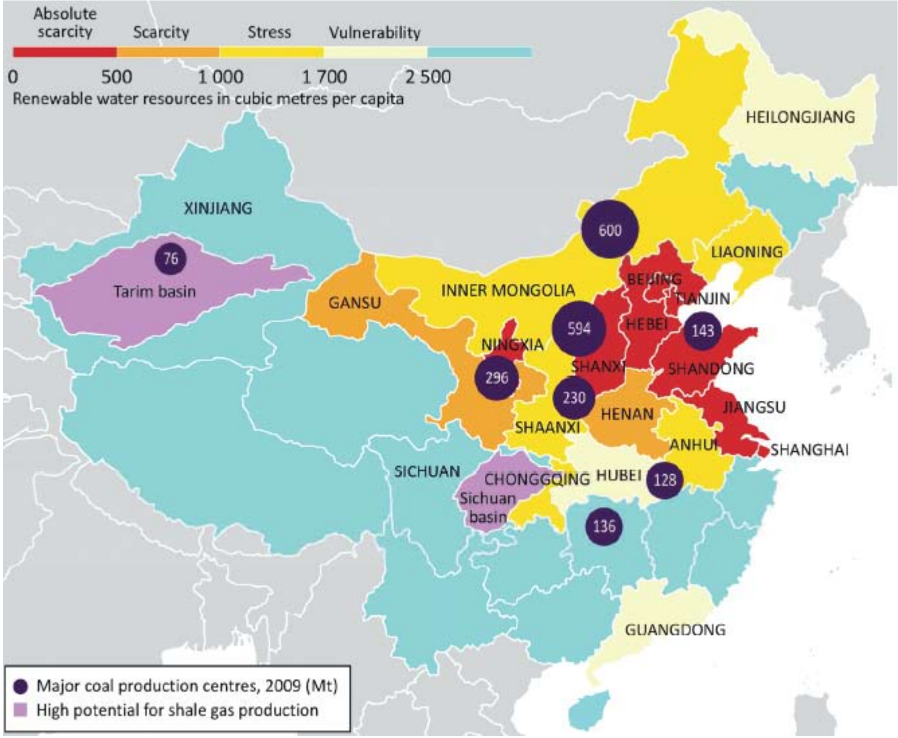
China, which is home to large cities like Beijing and Tianjin. Inconveniently, water resources are concentrated in the south while the largest population centers are found in the north. In an effort to alleviate this imbalance, China has launched ambitious infrastructure projects intended to move water from the south into its thirsty northern provinces. Many regions in China have been facing increasing droughts, resulting in water shortages that have disrupted both agriculture and industry operations. These water shortages in China are already resulting in significant economic loss and social instability. An August 2009 drought left 5 million people and 4.1 million livestock without drinking water, and destroyed 8.7 million hectares of cropland. This followed a rare winter drought, which impacted 10 million hectares and left 4 million people and 2 million livestock without adequate water. The next year, a particularly bad summer drought left 16 million people and 11 million livestock without water for days, and affected 51 million people in total. The drought also "paralysed" 90% of hydroelectric power stations throughout the Yunnan Province and the Guangxi Zhuang autonomous region in Southwest China, causing $2.8 billion in direct economic losses. In 2011, a drought forced the city of Shanghai into controlled rolling blackouts for some of its factories because there was insufficient water to generate the demanded electricity. Researchers estimate that water shortages in China are responsible for direct economic losses of at least US$35 billion per year, or 2.5 times the average annual losses due to flooding. Beyond economic impacts, in rare instances water conflicts have resulted in violence. In 2009, more than one hundred people were killed in clashes between riot police and villagers when over 10,000 villagers protested the safety of drinking water in Fujian Province.

In an effort to address these water scarcity concerns, Chinese planners are advancing water-pricing reforms and increasingly tough regulations intended to promote conservation. The Twelfth Five-Year Plan (2011-2015) prioritizes reducing water consumption per unit of industrial output by 30 percent, a plan rendered less feasible by simultaneously calling for increased water-intensive coal consumption. The government set water withdrawal caps at 635 billion cubic meters for 2015 and 700 billion cubic meters in 2030 and introduced targets to increase water use efficiency. China's National Climate Change Program encompasses a "commitment to reduce the vulnerability of water resources" and promote "rational exploitation" of water. To complement these measures, China is building major desalination plants in an effort to increase freshwater resources.

Despite these efforts, two independent assessments indicate the likelihood of future water conflicts. The first, from the nonprofit group Circle of Blue, looked at the confluence of coal use, water use, and economic growth in China. The study projected a 30 percent increase in coal-fired generation capacity by 2020, but warned that such additions will double the water use of the sector. Circle of Blue also cautioned that climate change will interrupt snowfall in the northern regions dependent on snow melt as a source of water for coal mining and coal-fired electricity generation. The assessment concludes that "there is considerable evidence of a potentially ruinous confrontation between growth, water, and fuel already visible across China and virtually certain to grow more dire over the next decade."

The second assessment, from the International Energy Agency (IEA), noted that "China's water resources are set to become more strained with the country's on going urbanization," and that water scarcity poses "a potential bottleneck to economic and social development." As Figure 1 illustrates, China's regions of highest thermoelectric capacity are located in water stressed areas and places of "absolute scarcity. "The IEA projects that water withdrawals for energy production in China will rise almost 40 percent, approximately 40 billion cubic meters, between 2010 and 2035. Water consumption will increase by 83 percent over the same period, to a total of 14 billion cubic meters annually. The IEA cautioned that "while all existing nuclear plants in China use seawater for cooling, future plans include the development of inland nuclear power facilities that will add to competition for scarce water resources where the plants are sited."

Figure 1:Water and Electricity Overview for China, 2010



Source: International Energy Agency

THE ELECTRICITY-WATER NEXUS IN INDIA

While water scarcity in China is a serious concern, India's water situation may be even more dire. More than half of India's 1.1 billion people live in water scarce regions, and 73 percent of electricity capacity owned by the country's three large utilities—NTPC, Tata Power, and Reliance Power—reside in water-scarce or stressed locations. Heavily dependent on groundwater for irrigation and drinking, India has lost 15 percent of its aquifers to contamination and overuse. Moreover, India is already experiencing the effects of water constraints. In 2012, the Raichur Thermal Power Station shut down four of its eight coal-fired units because there was not enough water in the Krishna River. This crippling loss of more than 800 MW of thermoelectric capacity left Karnataka State with an unreliable and erratic power supply. The plight of Karnataka State reveals broad problems facing India's thermal plants. Most of India will be water stressed by 2050,and the World Resources Institute reports that climate change may decrease the country's quantity and quality of freshwater more quickly.

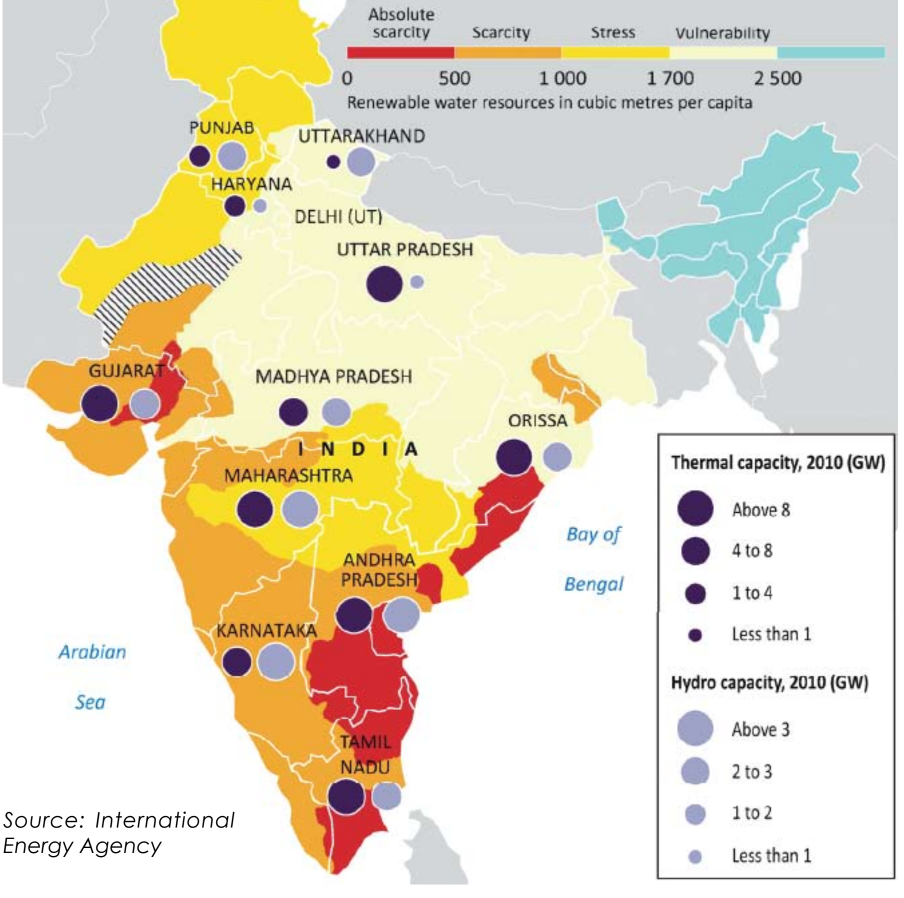
Despite these constraints, India's continued economic growth is creating a serious need for increased electric supply. With an installed capacity of 177 GW, India has the sixth largest electricity system in the world and is the sixth largest electricity consumer, even though 189 million Indians lack access to electricity. In 2011, conventional thermoelectric power plants—most of them coal-fired—produced about 80 percent of the country's electricity, making India the third largest consumer and the third largest producer of coal in the world. The implication is that India will need substantial amounts of water to accommodate both increased coal production and increased electricity generation.

At least four independent studies have raised similar concerns. The first, a 2010 joint report from HSBC Bank and the World Resources Institute, warned that planned investments in Indian thermoelectric and hydropower plants will occur in precisely the same regions of the country that suffer the most water stress. The second study, from the Prayas Energy Group in 2011, assessed environmental clearances for large coal- and natural gas-fired power plants. The Prayas study noted that coal-based power plants represent 84 percent of these planned projects, and that such additions are more than six times the current installed thermoelectric capacity of 113,000 MW. However, this added capacity will collectively increase the amount of water needed per year by an estimated 4.6 billion cubic meters, and most of these plants are concentrated in areas that lack the water resources to support them.

The third study from Greenpeace in 2012 argued that the thermoelectric capacity India intends to add under its 12thFive Year Plan—more than 100 GW—will need an additional 2.5 to 2.8 billion cubic meters of water per year. This is the equivalent to the irrigation water of more than 400,000 hectares of farmland. Yet the study argued that "there seems to be no consideration of the cumulative impact of this water use when sanctioning projects."

The fourth, a 2012 report from the IEA, estimated that energy demand for the country will double, and demand for water will more than double. The IEA concluded that "the power sector, which accounts for the vast bulk of all water use by India's energy sector at present, remains the major source of incremental water use: it accounts for 98 percent of additional withdrawals and 95 percent of additional consumption during the outlook period." As Figure 2 depicts, every single state in India in 2010 was vulnerable and many states with large amounts of thermoelectric capacity were either water stressed, water scarce, or in absolute scarcity.

Figure 2: Water and Electricity Overview for India, 2010



Source: International Energy Agency

IMPLICATIONS FOR POLICY

Despite these overwhelming challenges, practical solutions are available to better manage the electricity-water nexus in China and India. The simplest is to alter permitting and licensing requirements for power plants so that they incorporate local water needs. For plants that are located in water-stressed regions, the incorporation of cooling technologies that significantly reduce the use of fresh water, such as dry cooling or wastewater cooling should be mandated.

The current Chinese electricity regulatory framework does not have any requirements for considering water in plans for new electricity generation projects. The national body for electricity regulation, the State Electricity Regulatory Commission, does not appear to pay specific attention to water resources when undertaking its regulatory programs. Similarly, the agency responsible for permitting new electricity generation, the National Energy Commission, does not consider water resources when deciding to permit new construction. However, the framework requiring discrete consideration of water issues when permitting new generation is already in place. The NEC, or provincial governments, could decline to issue permits unless water is expressly accounted for in Environmental Impact Assessments.

A second solution, closely related to the first, is to bolster the existing Chinese Water Law with language requiring hydrological assessments for electricity generation projects. The Water Law charges the Ministry of Water with-regulating the nation's water resources. Since electricity generation consumes enormous amounts of water, this type of development could fall squarely within their mandated purview. Amending the Water Law to explicitly grant the Ministry authority to reject electricity development plans may also prevent construction of new generation facilities in water stressed areas.

Similar to China, India's electricity market is regulated by the Central Electricity Regulatory Commission a national agency under the Ministry of Power. CERC is responsible for the development of India's grid, and it is vested with licensing and permitting power for new intrastate generation projects. While the Central Water Commission is the primary authority for India's water resources, CERC is better positioned to consider water scarcity in the permitting process. To achieve this end, CERC could mandate that any new license or permit must be accompanied by a detailed assessment of its projected hydrological impact. As with China, implementing this type of procedure should provide a sufficient balance between meeting projected energy demand and mitigating the impact of constructing new water intensive energy projects in water scarce regions.

In short, electricity development in China and India has begun to face severe water constraints. Overreliance on water-intensive thermoelectric power plants has decreased system reliability during times of water shortage and stress. Droughts in both China and India have already forced power plant shutdowns and decreases in production. Rapid and continuing economic and population growth will further stress water resources as demand for electricity continues to increase. This is especially true when agriculture and electricity generation compete for limited water resources. As a result, planners in both countries must urgently find new ways of recognizing the importance of water when permitting and licensing new power plants. Far better to respond proactively, now, than to be forced to react hastily, and perhaps ineffectually, in a few decades. **AW**

Benjamin K. Sovacool, Sara Imperiale, Brian Thomson, Alex Gilbert *and* ***Jay Eidsness*** *work for the Institute for Energy & The Environment, Vermont Law School, United States.* ***Ajith Rao*** *works for the Regulatory Assistance Project, United States. Please email the editor of Asian Water at sahana.singh@gmail.com for their contact details.*