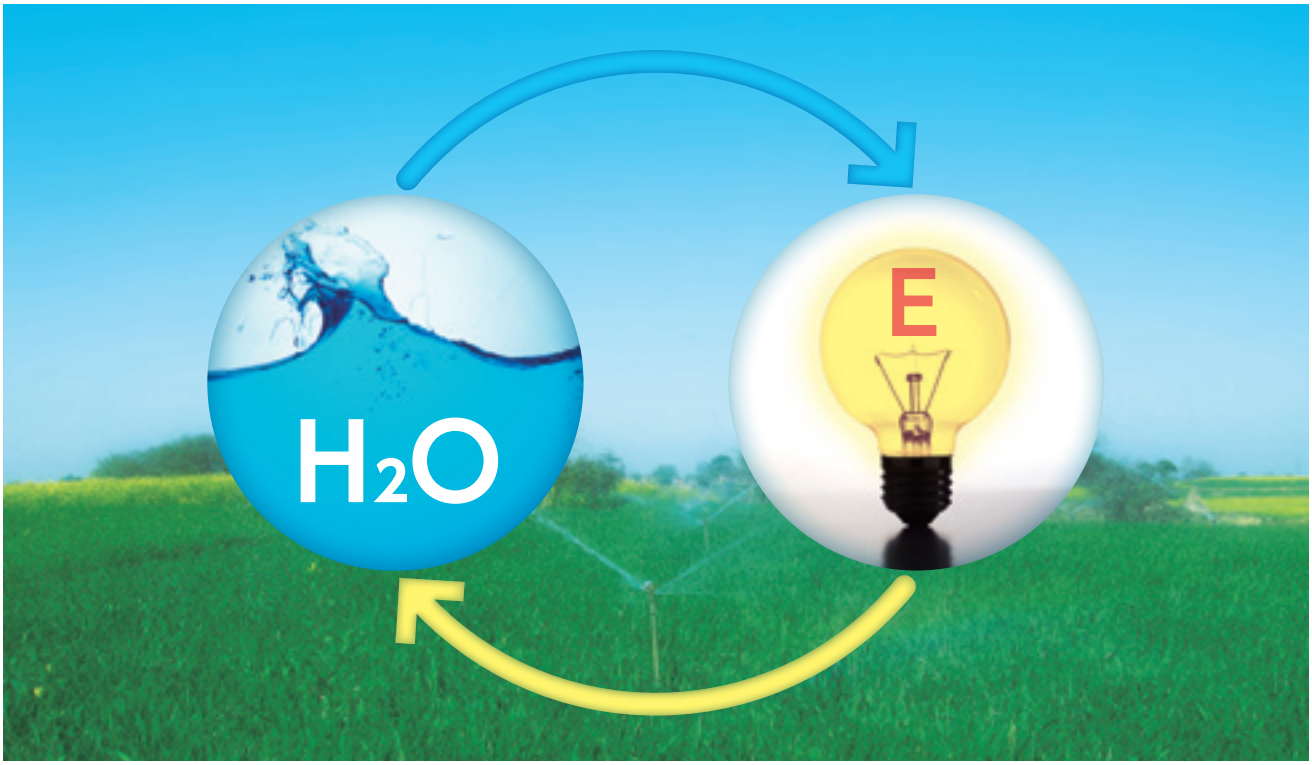


POLICY BRIEF

July 2012
Number 20

Long Term Electricity Scenario and Water Use — A case study on India

Key Messages

- Increasing water demand for electricity generation will intensify inter-sectoral conflicts for freshwater, especially in the countries with water scarcity like India. To mitigate conflicts for freshwater, appropriate policies should be taken in a timely manner. Such policies could be the introduction of water efficient technologies in power plants, promoting low water consumptive renewable energy (wind, solar photovoltaic) and the implementation of water demand management approaches for major water users.

- Water constraint is suspected to be a major hindrance for sustainable development of water scarce developing countries such as India to follow the existing projected electricity scenario to fuel desired economic growth.

- With the given technological intervention and its mid to long-term projection in India especially in the electricity sector, it is estimated that by 2050 water demand for electricity generation will increase by fivefold compared to 2010. Such an increased rate of freshwater use for electricity generation will exceed the capacity of total utilisable freshwater to meet total water demand by 2050.

Bijon Kumer Mitra

Associate Researcher
IGES Freshwater Sub-group
b-mitra@iges.or.jp

Anindya Bhattacharya

Senior Energy Economist
IGES Economy and Environment Group
bhattacharya@iges.or.jp

1 Introduction

While competition for water is intensifying around the world, growing energy demand will further increase conflict for this resource. Energy policy decisions will have significant influence on future water security. Many countries are revisiting their energy policies for sustainable energy production, and considering putting emphasis on carbon mitigation, cost and security (Glassman et al. 2011). However water as an agenda has yet to be well addressed in energy policies in most of the cases. In recent years the inter linkage nature of water and energy has gained special attention in regional and international platforms considering long-term challenges in terms of their growing demand. Water energy nexus is more critical for water scarce regions with emerging economies in Asia including both China and India. In this report, we deal with India as a case study country to further investigate the seriousness of the water energy nexus from a long-term perspective. India is one of the water scarce countries in the world with only about 4% of the world's total utilisable freshwater resources. The National Commission for Integrated Water Resource Development (NCIWRD) (1999), India estimated that only 1122 billion cubic meters (BCM) of water is utilisable per year at the current level of supply and demand. By 2050, water demand will grow to almost 1300 BCM, compared with the current supply of about 750 BCM, putting all development activities under threat. The per capita freshwater availability has dropped from 8192 m^3 early last century to 1730 m^3 in 2006, which is dangerously close to a water stressed condition (1700 m^3) and it is projected that this availability will further drop to 1240 m^3 by 2030 which is close to a water scarce situation (1000 m^3) as per the Falkenmark indicator (Falkenmark 1989) .

India is one of the hot spots of economic development in the world, but it is envisaged that this growth will be challenged by the growing water shortage. Beside various reasons for the increasing water crisis (population growth, industrialisation, green revolution in agriculture and climate change), energy production is one of the potentially major sources of water shortage in the mid to long-term in India. For example, high water consuming coal-based inefficient electricity generation is likely to predominate the electricity supply mix in the foreseeable future in India and it is suspected to put immense pressure on the freshwater resource stocks of the country unless water use technologies in the power plants are advanced adequately. However, national energy policies have so far not put enough attention on this water and energy interlink and corresponding trade-offs.

2 Water for energy - a major concern of increasing water crisis

Electricity generation capacity of India is the fifth largest in the world. However, per capita electricity consumption (543 KWh/capita) is ranked below the world average (2752 KWh/capita) (IEA 2011). The electricity generation capacity is dominated by coal-based thermal power plants (56%) followed by hydropower (21%). A huge volume of water is required for thermal power generation especially in the coal washing and steam cooling systems. Table 1 shows the comparative information on water requirement in electricity generation in the USA and in India under different fuel use categories. A report published by the Centre for Science and Environment (CSE), a national think tank in India, estimated that on average, the water requirement of electricity generation in India is about 80 m^3/ MWh for a coal-based power plant which is about 32 times (2.53 m^3/ MWh) higher than the same in the United States (DOE 2006). According to the Ministry of Water Resources, India, the demand in the country for water in energy production will increase 16 times by 2050, while the demand for drinking water will double and irrigation demand will rise by 50%. Given the availability of indigenous energy resources which is primarily coal in India and its projected energy supply portfolio, it is envisaged that projected power generation might intensify a water scarcity situation in the coming decades due to more demand for water as thermal power generation increases in the country.

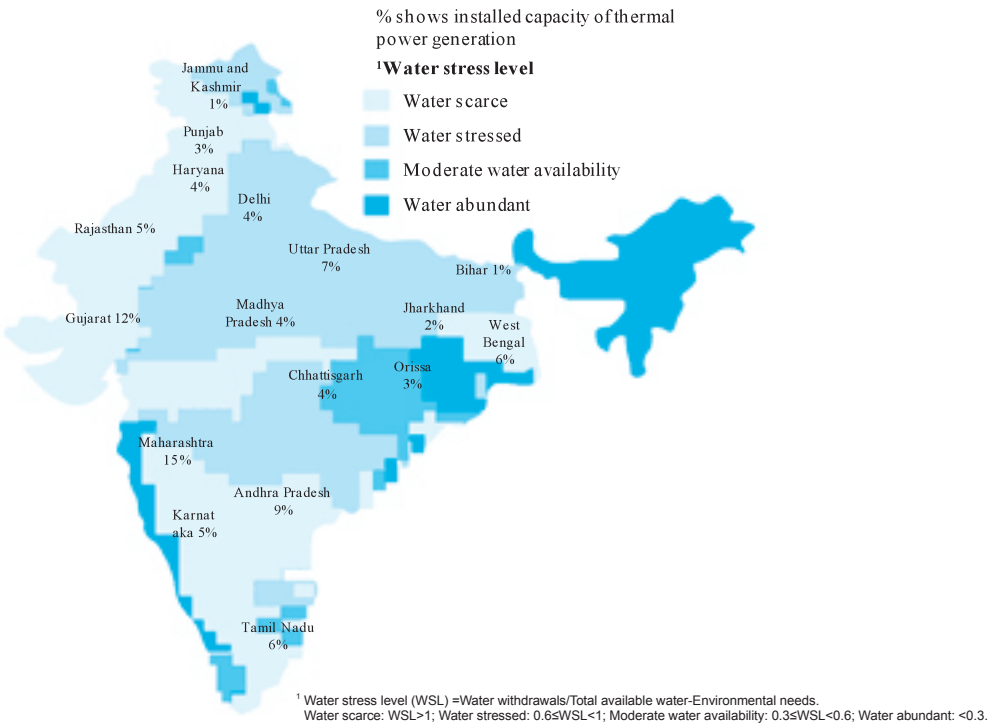
This situation can of course differ depending on the region within India, as water availability and water use rates vary across the country. Nevertheless, the nationwide total availability of utilisable water may well become a major hindrance for the future development of the power sector and India may not be able to meet the huge levels of energy demand needed to fuel the desired level of economic growth.

Furthermore, Figure 1 demonstrates an apparent dichotomy in the electricity planning in India which often ignores the water availability issue in a serious manner. The figure also shows that more than 60% of installed thermal power plants capacities were set up in regions where electricity demands are expected to remain very high; ironically all these areas are either water scarce or water stressed as per World Resource Institute definition. Unless there are appropriate measures taken to deal with the water scarcity issues from both technical and policy perspectives, it is quite likely that the planned electricity generation might be negatively affected or other water use requirements will be compromised. The bottom line is for net utilisable water per year to be more or less constant according to the government estimation. The portfolio of a projected energy supply will stress future challenges in the context of water use among various demand categories in India. In fact, some cases of conflict have already been reported in different parts of India (Box 1).

Table 1 **Water requirement of different fuel types for electricity generation**

Fuel type	Water requirement in India (m^3/MWh)	DOE, USA estimated water requirement (m^3/MWh) (DOE 2006)
Coal (Sub-critical)	80.0 (CSE)[1]	2.53
Natural gas	3.0 (NEERI 2006)	0.92
Nuclear	no data	3.82
Solar PV	no data	0.00
Wind	no data	0.00

[1] Estimation was done based on wastewater discharge data from "Water Quality in India, Status and trends (1990-2001), Central Pollution Control Board, MoEF" and annual electricity generation data from "Annual Report (2001-2002) on the working of state electricity boards and electricity department, Planning Commission"



[1] Water stress level (WSL) =Water withdrawals/Total available water-Environmental needs.
Water scarce: WSL>1; Water stressed: 0.6≤WSL<1; Moderate water availability: 0.3≤WSL<0.6; Water abundant: <0.3.

Figure 1 **Distribution of water stress level (WRI 2010) and installed capacity of thermal power generation (CEA 2011)**

Box 1 Water energy trade-off conflict in India

1. Opposition to Adani power projects is growing in Nagpur because the local community believes that this power plant will threaten not only the Pench Tiger Reserves but also the availability of water for drinking and irrigation. (Source: The Times of India 2011)
2. In Kerela, power cuts were imposed to tackle water scarcity in 2008 when the state received 65% less rainfall in monsoon than normal. (Source: Thaindian News 2008)
3. In Madhay Pradesh, power cuts were made to ameliorate the water scarcity in the state. (Source: Hindustan Times 2006)
4. In Orissa State, farmers protested the increasing rate of water allocation for thermal power and industrial use. In response to the farmers' opposition, the state government decided to give conditional permission to construct a thermal power plant that used seawater for cooling purposes rather than river water to avoid placing further pressure on the Mahanadi river basin. (Source: UNEP Finance Initiative 2010)

3 Long term scenario of power generation (2010-2050)

With the current economic growth rate and its corresponding increase in industrial, commercial and agricultural outputs in line with an increasing population, Grover and Chandra (2006) estimated that the average annual growth rate of electricity generation in India would be around 6.3% between 2002 and 2022. Projected electricity generation in India demonstrates an impressive trend of generation growth from between 2010 and 2050 as shown in Figure 2. By 2050, electricity generation is expected to reach around 4900 TWh, about 6 times that of 2010 levels and with an admirable average annual growth rate of 5%. As a result, per capita electricity consumption will reach 2898 KWh by 2050, which is nearly same as the current world average (2752 KWh/capita). The projected electricity generation portfolio also demonstrates the continued dominance of coal-based thermal power generation in the total electricity supply mix of the country until 2050. However, the ratio of contributions gradually reduces from 66% in 2010 to 57% in 2050. The contribution of natural gas-based electricity generation increases significantly to about 20% by 2050. Similarly, generation of renewable energy is also expected to increase in the future. Figure 2 below shows the projection of the electricity generation mix in India and their corresponding increase in water demand.

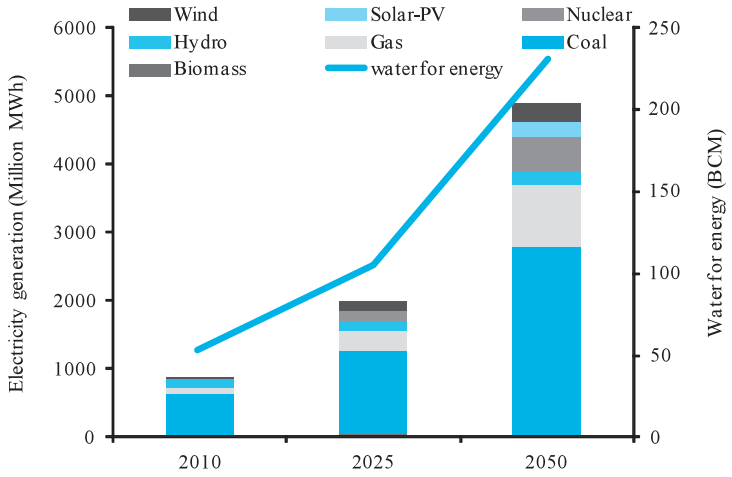


Figure 2 Estimated electricity generation projection and corresponding water demand in 2010, 2025 and 2050

4 Water footprint for electricity generation in India

Data on water withdrawal for electricity generation is not systematically available in India. Therefore, data has been compiled from various sources as shown in Table 1 to project India's total water requirement for electricity generation until 2050. If the current technologies for coal-based thermal power plants are continued, the projected electricity generation in 2050 will require approximately 227 BCM of freshwater which is about 20% of the total annual utilisable water in the country (1122 BCM).

Figure 3 demonstrates the comparison of different estimates of total water demand for electricity generation in India and their corresponding impact on utilisable water resource. The National Commission on Integrated Water Resources Development (NCIWRD) projected that water requirements for electricity generation in 2050 will be around 70 BCM using the government estimate of water requirement rate. This demonstrated that the total water demand will be less than that of the total utilisable water resources in 2050. Based on our IGES estimate, the total water demand exclusively for electricity generation will be around 227 BCM by 2050, which will create a deficit of around 100 BCM (exceeding by 10% of the total annual utilisable water) in terms of annual water supply and demand gap. Such significant difference in water use could be further attributed to being heavily dependent on inefficient coal-based power plants, operating with low quality coal, and with high water intense cooling tower technologies. It has been observed that the projection is much severer than national government projection on water availability for electricity generation. The projection shows that by 2050, Indian electricity generation together with other sectors will exceed the total utilisable annual water availability in the country.

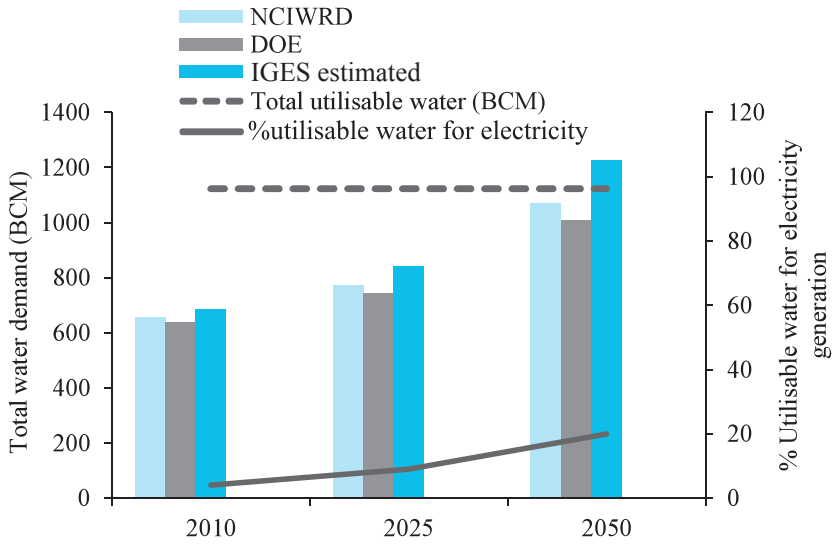


Figure 3 **Projected water demand for electricity generation and impacts on total utilisable water**

5 Multi-user trade off in water use and regional variation in scarcity

While it is suspected that by 2030 India as a whole will become more or less water scarce due to various hydrological, demographic, climatic and environmental reasons. It is estimated that 135 m^3 of per capita utilisable water (664 m^3) will be needed additionally for electricity generation by 2050. This is the expected water footprint per capita for electricity generation in India by 2050 which is approximately 20% of per capita total utilisable water. Figure 4 demonstrates the exclusive need of water for electricity generation

which is being used by the respective sectors. This instigates trade-off and conflict among other water users in the country especially among agricultural and residential use. Figure 4 shows the increasing water demand corresponding to electricity needs in residential and industrial sectors. Such increasing water demand is attributed to the increasing level of electrification. Similarly, water demand corresponding to electricity needs for the agriculture sector increases over time mainly due to the increased energization of agricultural activities like electrified irrigation pumping. It is estimated that India will have more than 6% per annum electrification ratio which will be a substitute for other primary energy resources like coal, kerosene, oil etc. As a matter of fact, electricity generation will not only increase the water intake for its own use but also increase the embedded water use for other sectors using electricity as source of energy. By 2050 the incremental water demand in domestic, industry, and agriculture sectors corresponding to electricity needs in the sectors will be 41 BCM, 63 BCM and 40 BCM, respectively. It is estimated that incremental water demand related to electricity use by the sectors will create water scarcity for 7.25 million ha of irrigated cropland and about one third of the projected total population (650 million) will face difficulties in accessing water for domestic use by 2050. However, the relative severity will be varied according to region depending on local renewable water availability, the type of dominant water users, population density, and any trends of land use change and political power of the water user groups.

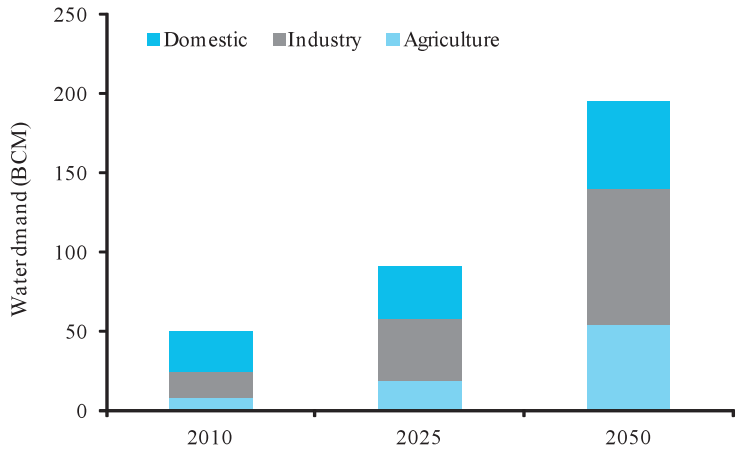


Figure 4 **Water demand corresponding to electricity needs in different sectors.**

6 Findings and way forward:

On the one hand, electricity generation will increase several times over in the coming decades in India which is primarily attributed to its rapid economic growth, and on the other hand, availability of utilisable water per capita is steadily decreasing due to the pressure of rapid population growth, economic development, and other social factors. It is envisaged that projected electricity generation will intensify this situation further and will deepen water crisis and intersectoral conflict in the absence of proactive actions. Early action on water resource management and technological development to reduce water use for power generation can ease the water situation in the long run. However, there is a severe data availability problem especially in the context of water requirement of electricity generation under different fuel and technology categories which are the keys for assessment of total water requirement for electricity generation. An attempt has been made in this study to investigate the nexus of water and energy based on limited data availability which reveals the enormous scope of further investigation and systematic study on this matter. Furthermore the following suggestions have been made based on this assessment of water energy

interaction in India for further consideration:

- In the water stressed region, long-term water availability should be one of the major indicators for power plant site selection along with other indicators including availability of energy resources.
- Although low-cost thermal power generation is expected to be predominant for the foreseeable future, but it is important to consider high water efficient technologies such as advanced cooling towers and dry cooling systems. This is to reduce the water footprint of electricity generation. Overall thermal efficiency improvement is also needs to be considered in the power plant management system.
- Promotion of renewable energy (wind, solar photovoltaic) would reduce pressure on water resources. But concentrated solar power (CSP) generation requires more water for cooling than any other fuel sources. CSP plant can be considered only in the area with abundant water resources.
- Countrywide systematic collection of water requirement data for electricity generation needs to be implemented. Monitoring and reporting of water requirement should be mandatory for power plants.
- Increasing water demand associated with growing energy demand is not well understood by the stakeholders due to the complexity of the system, unavailability of relevant data and information and lack of research. Therefore, research activities need to be promoted on water energy nexus issue which can provide insight into the close cyclical inter linkage between water and energy on the supply and demand sides of both of these resources.

Finally, the findings from India revealed that the integrated water-energy policies are essential for sustainable development in the water scarce countries.

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Institute for Global Environmental Strategies

2108-11 Kamiyamaguchi, Hayama, Kanagawa, 240-0115 Japan
TEL : +81-(0)46-855-3700 FAX : +81-(0)46-855-3709 E-mail: iges@iges.or.jp http://www.iges.or.jp

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