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GY

Coal dependency

Allowing private merchant miners could strengthen the sector

Coal seam fires

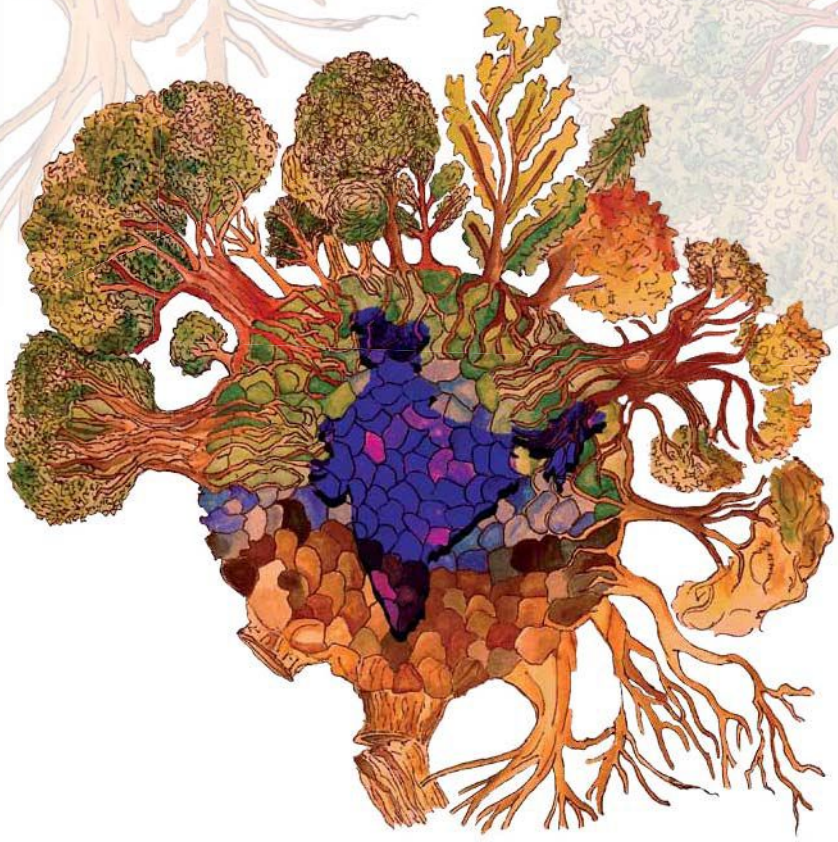
A seam on fire may continue to burn for thousands of years

COAL DRIVEN

An understanding of where, how and why coal is so important for India

ISSN 2347884-5

EVERY DAY IS EARTH DAY



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● SWITCH OFF LIGHTS, FANS AND ACs WHEN NOT IN USE ● REDUCE, REUSE AND RECYCLE WASTE ● USE LESS AND WASTE LESS WATER ● CARRY A JUTE OR COTTON BAG INSTEAD OF A PLASTIC ONE ● REUSE WASTE PAPER WHEREVER POSSIBLE ● WALK OR CYCLE SHORT DISTANCES ● PLANT SAPLINGS ● EAT LOCALLY GROWN FRUITS AND VEGETABLES.

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COAL DRIVEN

SANITATION PERSPECTIVES

DISASTER MANAGEMENT

INDIA OUTDOORS

REPORT WATCH

IN BRIEF

Coal powered brick kilns dot Bagaha, Bihar in multitudes resulting in heavy air pollution.

PHOTO: RANIGANJ, WEST BENGAL; AMAR KUMAR NAYAK

Dear Readers,

India's economy is driven by coal. Mining, especially the opencast type practiced in India, requires large tracts of land to be stripped apart. Apart from this the number of environmental challenges associated with coal power is huge—soil erosion, dust, noise and water pollution, and impacts on public health and local biodiversity. However, we are nowhere near giving up coal in the future. In order to sleep with the enemy, we need to take urgent steps to modernise mining and power operations. Going by several news and not-for-profit organisations' reports, life around mining areas or thermal power plants is bleak. The water and air quality in these regions are deteriorating abysmally. Moreover, technologies to clean up the act is expensive. Thus modernising operations or installing new 'clean' measures is a tall order.

Countries all over the world are moving away from coal to either petroleum or renewables. We, however, continue to tread the developmental path abandoned by many, and are destined to depend on coal for our energy needs. Although India has an ambitious renewable agenda, the sector is poorly organised. The capacity addition notwithstanding, actual augmentation of energy needs in terms of electricity produced, is still nominal. Coal powered development, much in the same way as petroleum is a multi-crore business. Stakeholders are likely to lobby for continued access to polluting power. It is only unfettered political and civil society's will that can turn this around and usher in an emission-free future.

This issue has dedicatedly covered every aspect of coal. A sub-section deals with sanitation, global reports and urban flooding, a challenging new phenomenon that calls for better planning.

Happy Reading.

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G'nY ran a debate about India's education scenario between April 12 and 13, 2015 on 'Geography and You-Facebook'. Readers were asked to respond to the need and quality of education in India in the backdrop of a parallel education system, especially coaching that operates bereft of a degree. Despite the fact that coaching institutes may have a good method of teaching and often can impart more education in a short span of time than many other 'reputed' institutes, yet the fact that these places do not have any authenticity and at the same time charge heavily, is what the debate is about. The respondents were asked whether this parallel system should continue, or whether governmental aided educational institutes should work harder to fill the gap.

For more details log on to our website **www.geographyandyou.com**

YEAR AFTER YEAR, the Indian education system tries to aim at quantity instead of quality; perhaps because quality of education is difficult to measure as compared to quantity. This results in the mass production of graduates armed with degrees, yet lacking basic skills for the job market. This is where the parallel education system steps in. They try to bridge the knowledge gaps of a student by charging obnoxiously high fees and offering quick fix solutions. This parallel education system is not a disease but the symptom of a disease. The main problem is our sick education system. Students enter schools and colleges not to learn but to get degrees. This needs to be reformed by allocating more funds for the education sector and improving it in terms of quality with better teacher- student ratios, infrastructure, skill training, and the like. We need to act fast as we are on the cusp of demographic dividend. The youth of this great nation is waiting for an education revolution.
—SAM JOE

OUR EDUCATIONAL SYSTEM needs to be geared toward skills. There is no match between skills and jobs offered. Graduates in geography, such as me, are unfortunately, offered only teachers' posts by the Kerala Public Service commission in our State. Is there no other opening?
—ASWIN UNNIKRISHNAN

INDOCTRINATION IS WHAT goes by the name of education today. A student is stuffed with facts and expected to be ready for a job. There is no development of personality or modification of behaviour for the better, with values that can nourish an individual. Producing good quality economists can certainly lift our declining economy, but only if it is propped up on quality education that provides the right values and ideals to every individual.
—ASHFAQ AHMAD MIR

THE GOVERNMENT NEEDS to put vocational courses in place. It should remain facilitating such education with proper funding, infrastructure and policy making. All vocational and specialised higher education and research should be handed over to industry, so that students are imparted the right skills needed for jobs in the commercial sector. It can confine itself with general education in science, commerce, arts, culture, and mass schooling.
—N C MEENA

THERE IS A POLICY PARALYSIS in implementing and imparting education. Significant amounts are spent on fetching good grades and not on quality education. Morals and ethics are compromised and never paid heed to, without realising their significance for a civilized nation. At the primary and secondary level, education is merely a lucrative profit-making business. Students need to be trained in conceptual understanding to gain command over their subjects. For employment, job-oriented training institutes or industry–oriented institutes for skill development at the college level run by the state are the need of the hour.
—PRABHAKAR PRASAD

THE INDIAN EDUCATION SYSTEM is no system at all, if we look at the present scenario. Passing has become far easier and the quality has enormously declined. Maharashtra government, for instance, started the policy of encouraging non-grant private colleges. There were many more colleges to get admitted to, and admission became easier. The student who earlier needed at least 60 per cent in the science aggregate for getting admitted to an engineering or medical could now make do with just 35-45 per cent. The

education system was eased to make it universal, but we have ended up dropping the quality. Right now, we need responsible institutes and a responsible government.
—SWAPNIL WANKAWAR

YES, THERE SHOULD BE a change in the education system. Education should breed confidence, virtue and values. Education should never mean rote learning of facts.
—RAJESWARI RAO

HOLISTIC EDUCATION IS the need of the hour. Concepts should be strengthened to build the right foundation on which knowledge is acquired. Students need to be guided with the right amount of love and empathy by teachers to get ahead in life.
—DIVYA RAJU

THE PARALLEL SYSTEM IS worsening Indian education and affecting its net output. It is only adding to the woes of parents and their wards. It is high time we did away with the parallel system, and put in efforts to strengthen the existing government-run educational system with better finances and planning.
—SHAILESH KUMAR

VOCATIONAL COURSES ARE what we need to make our students self-reliant and job-worthy, if the country is to grow and develop.
—OGUNDIPE OLAOLUWA ADEBAYO

EDUCATION SYSTEM SHOULD change according to today's requirements, if the nation must grow.
—RINA SHAH

January-February 2015, Let me first congratulate the entire team of G'nY for bringing out such an important and topical issue pertaining to the livelihood of majority of India's population. The Land Acquisition Act 2013 passed during the UPA regime duly supported by the BJP was perfectly all right. The BJP leaders have not been able to defend their change of stand on the Bill so quickly. The promulgation of Ordinance twice has placed the government on a slippery wicket. The reaction of the government through its senior ministers does not hold water. For example, Ravi Shanker Prasad questioning the lack of legal understanding of Rahul Gandhi, said on television that government requires land for making canals for improving irrigation and land for making hostels for tribal students. It is ridiculous to hear that from a senior minister of the government. First of all, there was never a bar on acquiring land for public purposes viz. laying railway lines, making roads, making canals for irrigation etc. — you do not require a new law for acquiring such land. As far as the construction of hostel for tribal students is concerned, it can't be constructed in fields. State governments allot hundreds of acres of land to universities, most part of which remain unutilised. The state governments can easily earmark 10 per cent of this land for making hostels for tribal students. Further statistics show that large tracts of land already acquired and allotted are lying unutilised. The government should take all these facts in to account and not insist on changing the laws unnecessarily.
—RAJENDRA PRASAD, *Patna*

I AM A REGULAR reader of G'nY and through your magazine I want to express my views on the Land Acquisition Bill and government's stand on it. I can see an eerie similarity with the Lokpal movement and the Opposition's stand against the Land Acquisition Ordinance. The movement against the Congress gave birth to the Aam Aadmi Party. The fall out of the re-promulgation of the Ordinance has already made many parties come together and this will have a significant impact on the Bihar elections, which is not far away.
—SHAMS IQBAL, *Gwaliar*

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By **Sulagna Chattopadhyay**

Discovering Coal

The Gondwana bituminous coal in India is primarily found in the river valleys of Damodar, Son, Godavari and Wardha.

The plant inhabitants of prehistoric swamps serve as a source of coal. Peat, lignite, bituminous and anthracite are the major varieties of coal found.

PHOTO COURTESY: JHARIA JHARKHAND SAMRAT35

Unassuming it may be, the black lumps of coal at your barbecue party, but its strength is legendary. Coal has been one of the most widely used sources of energy either for domestic use, or a fuel for power generating plants or for that matter in railways and steamships. Before the humans knew that use of coal, wood and charcoal were used as fuels. The Graeco-Romans were the first people in history to use coal as a domestic fuel.

Gradually, its use spread to other countries in Europe where coal was used to keep homes warm in the cold weather. However, it was from the late 18th century onwards that coal began to be used in the steam engines and became the cornerstone of the industrial revolution in Britain. Thus began the commercial mining of coal in different countries. Today, apart from being an important source of energy, coal is used in the production of materials like tar, pitch (this is a solid volatile substance obtained from the distillation of coal in the total absence of air, not to be confused with coking coal), ammonia, fertiliser, drugs and also in the production of dyes.

Forests of Carbon

Large, heavy creatures roamed the earth millions of years ago. Dinosaurs were a reality in the carboniferous age. Move your mental eye away from the dinosaurs in the movie Jurassic Park, and focus on the lush trees and thick vegetation that provided the backdrop of heightened action. That lush vegetation is coal today. In the geological time scale Jurassic and Triassic are part of the carboniferous age.

Although scientists have unanimously admitted that coal is a product of plant origin, its region of production is open to debate. Some argue that coal originated in a sea full of algae or in lakes. Others argue that the vast quantities of wood fell into water bodies and produced coal *in situ*. A few think that great forests or woods were caught in a huge drift, pushed by a great flow of water, eventually producing coal.

It has been estimated that a 30 cm thick layer of bituminous coal required the deposition of plant remains for 125-150 million years while an anthracite layer of the same thickness required nearly 175-200 million years of deposition. For transformation of coal from plant remains, temperate to tropical climate and moderate to heavy rainfall was required. Transformation of coal began with biochemical erosion and ended with chemical conversion in presence of high temperature and pressure exerted by the overlying sediments. In fact almost all the delicate parts of a plant are preserved and ultimately transformed into coal. Over time, layer upon layer was laid down, giving rise to the sedimentary process. Followed by intense heat, and compression, earth movements and contortions, the vegetation was compacted and the carbon in it turned to coal.

Coal Forming Forest Plants

Leaves, stems, spores, tree trunks, branches, plant roots, resins, charred wood from swamp fires, other organic and mineral (inorganic) matter were deposited within the ancient swamp basin. Accumulation of mud, silt and other sedimentary rock forming substances with these materials, constitute a coal bed. Coal, therefore occurs in a series of layers called 'seam' which are separated by layers of other rocks. A stratified scale can establish the age of coal deposits and their position in allied beds. Such specific information can establish the suitability of coal for energy production, chemical separation and manufacture of steel.

The plant inhabitants of Palaeozoic-Mesozoic (and to some extent Cenozoic) swamps serve as a source of coal. An enormous number of fossil evidences recovered so far prove the presence of world's first great forests in the permo-carboniferous period. This forest association, comprising a variety of plant groups such as lycopsids, horsetails, ferns, pteridosperms, coniferophytes, etc., had faced mass extinction at the end of Permian (about 250 million years ago). The complete burial and transformation of these plants resulted in the Carboniferous coal (estimated age 280-360 million years), which today constitutes the majority of the world's coal deposits.

Besides coal of Permo-Carboniferous origin, formation also took place in three other geologic periods. Thus we have Triassic coal (estimated age 205-245 million years), Cretaceous coal (estimated age 70-140 million years) and Tertiary coal (estimated age 2-70 million years). Plant groups like ferns, cycadophytes, ginkgos, coniferophytes and few primitive angiospermous members

Carbon gives coal its **COLOUR AND ALSO DETERMINES ITS HEATING CAPACITY.** But, hydrogen, nitrogen, and substances like sand, mud and gravel dilute coal's darkness.

Fig. 1: Different Stages of Coal Formation

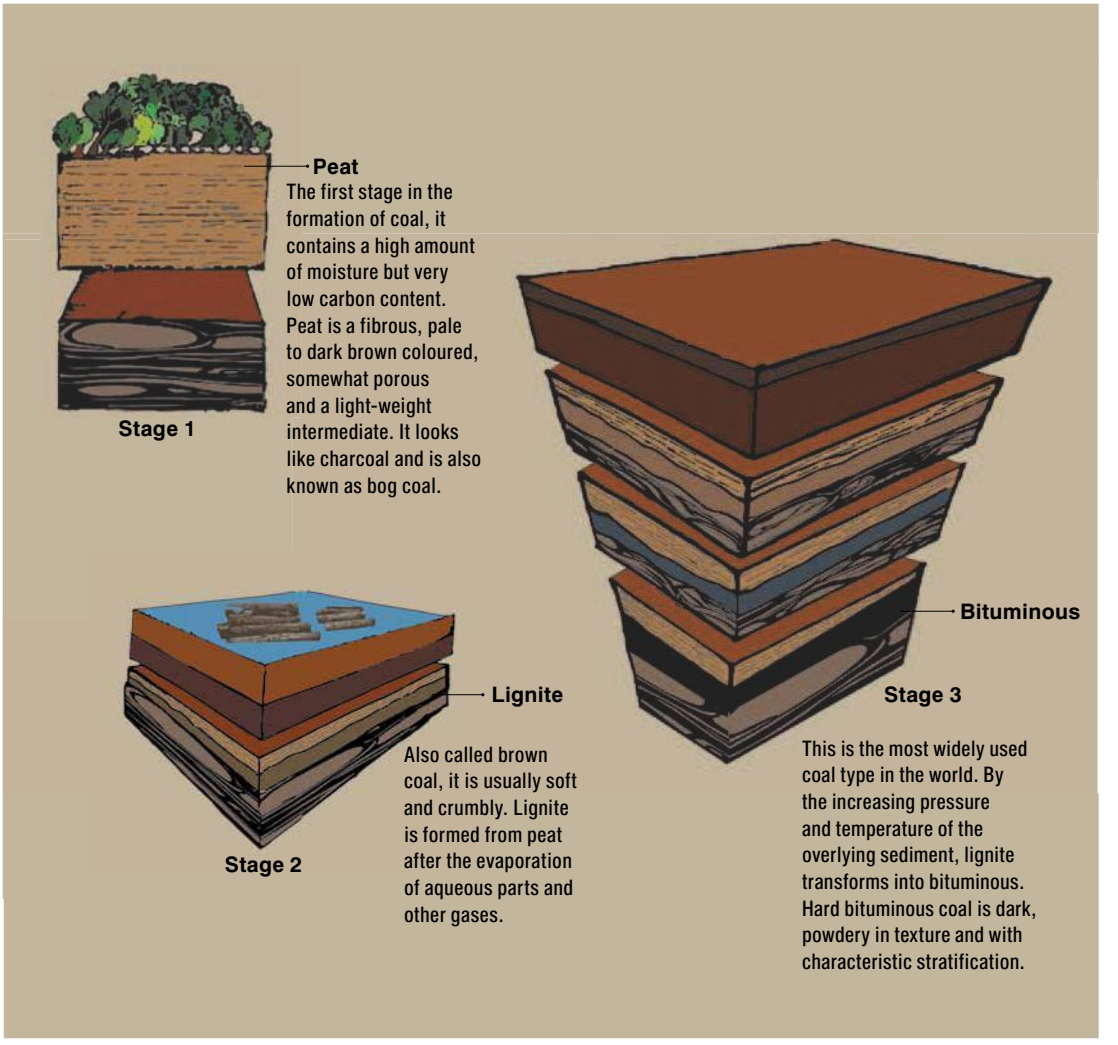


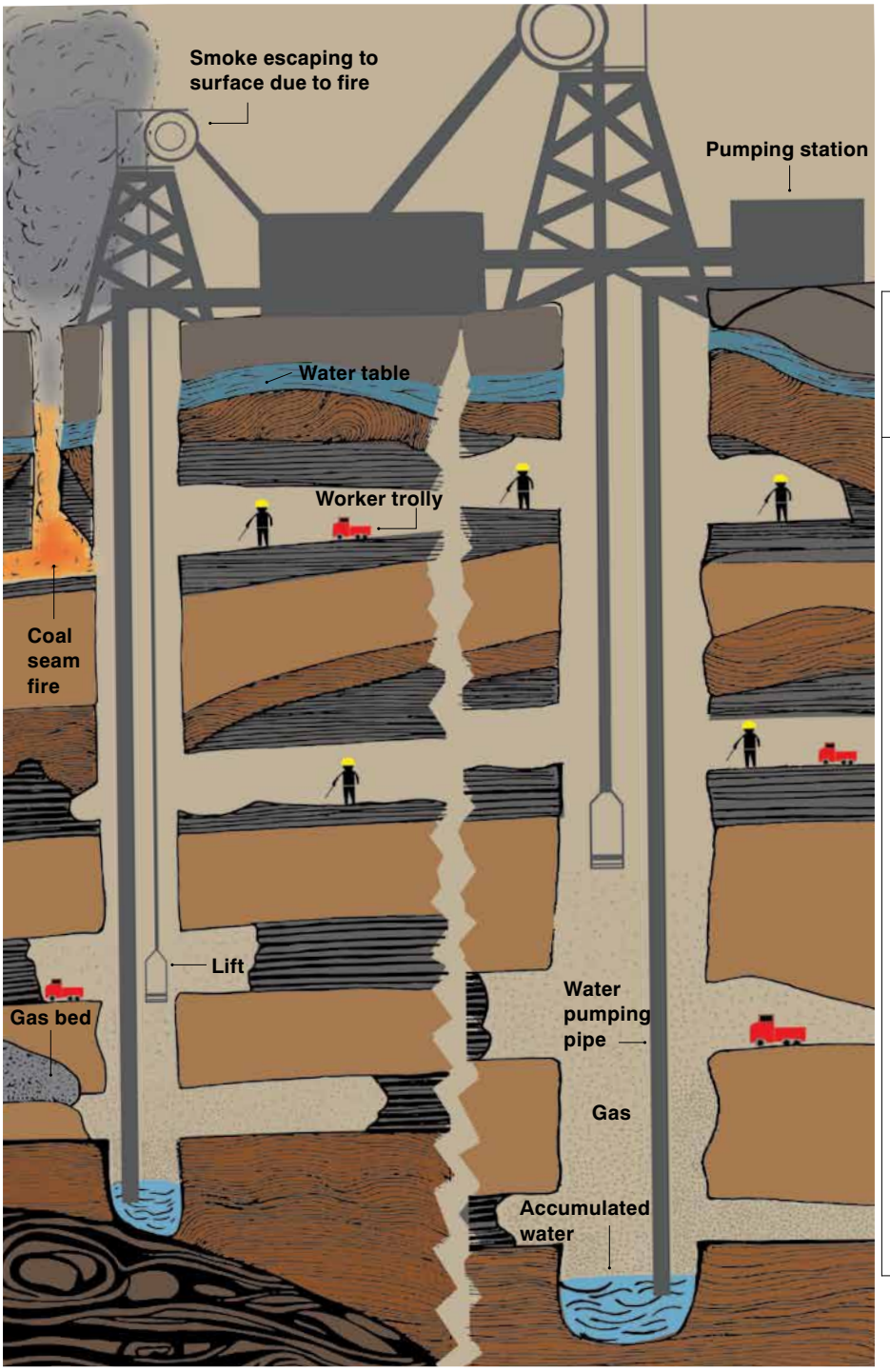
ILLUSTRATION: PRERONA MAJUMDER

shared the status of Mesozoic (both for Triassic and Cretaceous) coal formers. Tertiary coal, the youngest among the world's coal deposits, evolved from perfect preservation of certain deciduous angiospermous genera, ginkgos and some conifers.

Coal is not always Black

Although chemically coal contains carbon, which not only gives it its colour but also determines its heating capacity, hydrogen, nitrogen, and substances like sand, mud, gravel dilute and deplete its darkness. Diluters of coal's dark beauty such as sand gravel, mud and moisture, lower the heating capacity too and render certain deposits useless. A classification based on heating capacity and impurities is given below:

Fig. 2: Shaft Mining



Vertical shafts are sunk to reach the coal bed, and a network of galleries is dug underground. Lifts or box like cages are used to access the mine. Often explosives are set in the coal face for loosening coal into lumps. Shaft mining is the most expensive of the mining methods because of the overhead costs of ventilation, lighting, water supply and underground haulage. The mining company also must take precautions against such possibilities as gas poisoning, explosion, floods and the collapse of tunnel roofs.

ILLUSTRATION: PRERONA MAJUMDER

Opencast mining or stripping is the easiest way to mine. It hardly disturbs the underlying strata, although **LARGE TRACTS OF AGRICULTURAL LAND** may be devastated.

Peat: It is the first stage in the formation of coal and contains high amount of moisture but very low carbon. In a normal fossilization process, coal formation begins when vegetation is buried and partly decomposed to form peat. Peat is a fibrous, pale to dark brown, somewhat porous and a light-weight intermediate. It looks like charcoal and is also known as bog coal. Because of the low carbon content (i.e. 25 to 30 per cent), peat has a low heat value, and therefore it is not generally used as an industrial fuel. Its calorific value is only 75 therms per tonne as compared to bituminous, which is approximately 275 therms.

Lignite: Also called brown coal, as it is usually brownish in colour and crumbly in texture. Lignite or soft brown coal is formed from peat after the evaporation of aqueous parts and other gases. Lignite is mainly used for preparation of petrol and natural gases and warming-pans. Lignite has a high moisture content and emits a lot of vapour and smoke when burned. It is soft in disposition, has little heat value (because its carbon content is only 35 to 40 per cent and the calorific value is even less than 24 megajoules/kg) and easily cracks and crumbles when exposed to air. It is generally used only as a supplement to bituminous or anthracite.

Bituminous: It is the most widely used coal type in the world. By the increasing pressure and temperature of the overlying sediment, lignite transforms into better quality bituminous. Comparatively hard bituminous coal is powdery in texture and with characteristic stratification. It generates less amount of smoke during burning and is mainly used in industries, thermal power plants, households, steam locomotives and in gas production. Its carbon content is very high, about 80 per cent, giving it a black appearance and a hard texture. Its high carbon content also renders a high heat value of 26.7 megajoules/kg. In addition, low emission of smoke and minimal deposits makes bituminous coal the most popular industrial choice. It is this coal when heated in a special oven produces coke, which is an essential raw material for the iron and steel industry.

Another type, i.e., sub bituminous is a coal whose properties range from those of lignite to those of bituminous and are used primarily as fuel for steam-electric power generation. It may look dull, dark brown to black, soft and crumbly.

Anthracite: It is the hardest and the best type of coal with a shiny black appearance. With a carbon content above 90-95 per cent and little impurities anthracite's heating capacity is higher, burns longer and leaves little residue and smoke. Yet anthracite, though the best, is not popular. Firstly, because the deposits are scarce, and secondly, because it's the hardest coal mining is not only difficult but expensive too. Thirdly, anthracite has a high ignition temperature, and takes a long time to kindle. Thus, anthracite constitutes only about 5 per cent of the total coal production of the world and, is not commonly used in industry and transport. However, it may be used for domestic heating, bakeries and for boilers.

Extracting Coal

Man has discovered many ways to access this useful resource. Some of the methods are listed below:

Stripping or opencast mining: Opencast mining or stripping is well suited for areas where coal seam lies at or near the surface not more than 60 m deep. The seam should be more or less horizontal with the prerequisite for a thin and soft overlying strata, very much like a crumbly black current pie. This is the easiest way to mine, as it hardly disturbs the underlying strata, although large tracts of agricultural land may be devastated. Modern conservation techniques can now restore former areas of opencast mining, examples of which may be seen in the Appalachians and Australia.

Hill slope boring: Giant sized augers (boring instruments) are used to dig out coal on hill slopes. These augers can reach as far as 105 m below the ground.

Underground mining: Also known as drift or adit mining where a tunnel is cut into the coal bearing stratum. This type of mining operation is undertaken in hilly areas, where there is a slightly inclined or horizontal coal seam with a thick overburden.

Opencast mines continue to flourish in India. In the recent times, we are poised for a new coal driven revolution, even as nations across the world are moving away from it.

Slope mining: This is practiced in areas with steeply tilted coal seams or where coal is below a thick overburden. An inclined tunnel known as slope is constructed and a conveyor belt of a cable car is used for bringing out coal through the tunnel.

Shaft mining: This method of mining is used for reaching deep-seated seams (305 m to 1500 m below the surface). Vertical shafts are sunk to reach the coal bed, and a network of galleries is dug underground. Lifts or box like cages are used to access the mine. Often explosives are set in the coal face for loosening coal into lumps.

Shaft mining is the most expensive of the mining methods because of the overhead costs of ventilation, lighting, water supply and underground haulage. The safety in the mines has to be ensured by providing proper ventilation so that fire accidents don't occur. This also helps reducing health hazards for miners. Miners also need to be aided with better geological information pertaining to the seasonal movement of water tables in order to equip them against the danger posed by the crushing inflow of water. Also efficient pumping stations to pump the water out of the mines need to be placed. The mining company must take precautions against such possibilities as gas poisoning, explosion, floods and the collapse of tunnel roofs. GY

Email: editor@geographyandyou.com

PHOTO: HAULING COAL TO TRUCKS IN RANIGANJ, AMAR KUMAR NAYAK

Opencast extraction of good quality Gondwana coal in Jharia, Jharkhand.

PHOTO COURTESY: JHARIA,JHARKHAND; SAMRAT35

The great Indian coal

India possesses a significant place in the annual upraising of coal in the world. India is rich in bituminous, although traces of peat may be found in the Nilgiris and Jhelum valley of Jammu and Kashmir. The coal in India is categorised as Gondwana and Tertiary. Gondwana coal is that which is formed during the carboniferous age, and is found primarily in the river valleys of Damodar, Son, Godavari and Wardha. Anthracite is present in the Gondwana rocks of Eastern Himalayan foot hills and in the Eocene rocks of Jammu and Kashmir. Tertiary deposits indicate coal formed more recently in the geological age. These deposits have mainly resulted due to the earth movement that accompanied Himalayan orogeny. Lignite is obtained from Assam, Kashmir, Kerala, Rajasthan and Tamil Nadu. A trace amount of lignite is also found in the Darjeeling and Jalpaiguri districts of West Bengal. There are 15 coal producing states in our country among them eight major states are Madhya Pradesh, Jharkhand, Odisha, Andhra Pradesh, Maharashtra, West Bengal, Uttar Pradesh and Chhattisgarh. GY

Source: Geological Survey of India, Kolkata

THE COAL FILES

Coal is important for the economic development of our nation. But, is it so imperative that we ignore the bleak future the path foretells? The world has seen that and been there, do we have to pay the price too?

COAL MINING BANNED IN INDIA'S MAHAN FOREST

The Mahan forest in Madhya Pradesh will now be kept off limits for coal mining, due to a right to information (RTI) based intervention by Greenpeace (India), an international activist group working on environmental issues. Mahan in Madhya Pradesh is one of the largest sal forests in Asia. Spread across 1,600 hectares, it is home to over 50,000 indigenous people and endangered wildlife species. In June 2014, the Intelligence Bureau had accused Greenpeace (India) of acting against 'national interest' for opposing mining in the Mahan coal block. Protection of Mahan comes as a blow to Essar Energy, which hoped to mine the forest to supply coal for its nearby power plant. The Mahan tribes are entitled to a referendum about the envisaged development of the forest, which they say, have been bypassed. Many other coal blocks fall under dense forest areas, considered for mining, for instance, Marki Mangli II and Namchik-Namphuk. Mahan is indicative of how India will need to balance its economic growth while making key decisions about forests, conservation, and sustainable development. India is under a lot of pressure globally while tackling climate change, yet is drawn to the quick and cheap gains from coal despite the high social and environmental cost.

Source: RTCC News, March 25, 2015

VPT DRAWS FLAK FOR COAL DUST POLLUTION IN AP: PUBLIC HEARING ON PORT PROJECTS

The people of Visakhapatnam Greater City, have made a fervent plea to the authorities of the Visakhapatnam Port Trust (VPT) to stop handling dirty cargoes such as coal and protect the health of the two million residents in the city and its vicinity. The plea was made at a public hearing on port projects held near the administrative office here. VPT Chairman M T Krishna Babu tried to assure the irate public that the Port would take all possible pollution control measures and that in the next few years, Rs 200 crore would be spent on pollution control at the Port.

The people in the old city are suffering from respiratory problems and other maladies due to the pollution caused by the Port. Now, without taking any steps to control the present pollution, the Port is embarking on expansion of capacity. It was also pointed out that the environment impact assessment (EIS) report was full of flaws and no attempt was made to study the pollution issue seriously and find solutions. In response, Krishna Babu said the issues raised by the public would be taken note of and every effort would be made to address them.

Source: WebIndia123.com, April 10, 2015

COAL RUSH IN INDIA COULD TIP BALANCE ON CLIMATE CHANGE

Decades of strip mining have left the town of Dhanbad in the heart of India's coal fields a fiery deposit of black slag, sulphurous air and sickened residents. But rather than rethink their exploitation, the government is digging deeper in a coal rush that could push the world into irreversible climate change and make India's cities even more unliveable, scientists say. India's coal rush could push the world past the brink of irreversible climate change. Indian cities are already the world's most polluted and hottest, with spring temperatures in Delhi reaching 120°F. Traffic, which will only increase with new mining activity, is already the world's most deadly. And half of Indians are farmers who rely on water from melting Himalayan glaciers and fitful monsoons.

India's coal is mostly of poor quality with a high ash content that makes it twice as polluting as coal from the west. Nearly 90 per cent of India's coal is from strip mines, which are environmentally costly. Residents accuse the government of allowing pollution as a way of pushing people off land needed for coal rush.

Source: The New York Times, November 17, 2014

CONSERVATION GROUP SAYS COAL POLLUTION WILL KILL PEOPLE IN INDIA

The Indian group trying to stop a Galilee Basin coal mine development claims burning its coal will increase deaths. But miner Adani disputes the claim and states coal will produce less pollution than burning wood and dung, which is currently widespread in India. Indian group Conservation Action Trust (CAT), who have taken Adani to court to stop the Carmichael mine, released a report claiming coal would increase 'premature deaths' to 229,500 by 2030. The report said the increase in coal power generation would "seriously harm the health of the Indian rural poor", the basis of CAT's legal challenge.

But an Adani spokesman said CAT's models were flawed, and Indians were exposing themselves to far worse pollution. At the heart of CAT's claim lies a comparison to the rollout of thermal coal generation capacity in the emerging Asian economies such as China over the recent decades.

Adani's progressive plans to deliver power to those who lack it is underpinned by the rollout of supercritical technology that burns less fuel more efficiently, with substantially reduced emissions, compared to legacy infrastructure utilised elsewhere. The spokesman said that a US Energy Administration report showed two-thirds of Indians were burning biomass fuels for cooking and heating.

Source: Daily Mercury, December 11, 2014

COAL'S BLACK WIND: PREGNANT WOMEN IN PARTS OF INDIA ADVISED TO STAY AWAY

In some Indian regions, a married woman will return to her mother's house for the last trimester of pregnancy and the birth of her child. But in Mettur, pregnant women are advised by their doctors to stay away. 'Black wind' from a coal yard wafts constantly across poor neighbourhoods. People complain of asthma, wheezing and frequent colds. India relies heavily on energy from coal. Accounting for 71 per cent of electricity, coal will remain a key player over the next decade. The poor pay the highest cost of India's dependence on coal. Already burdened by chronic disease, poor nutrition and inadequate health care, they also are highly exposed to air and water pollution. In Jharia, 700,000 people are exposed to toxic smoke that seeps from the ground as fires from opencast coal mines burn. Mercury-laced ash from five mega power plants in the Singrauli district in central India is polluting air, water and soil. These areas are now mobilising documentation of coal's health impacts on their residents in an effort to gain environmental protections from local politicians and world leaders.

Source: Environmental Health News, November 20, 2014.

DEATH BY COAL

The Indian government's plans of expanding its coal-based power production may result in hundreds of thousands of premature deaths by 2030 due to increase in emissions. A report by Mumbai based non-profit, Conservation Action Trust, and Urban Emissions, an independent research group, estimates that in another 15 years between 186,500 and 229,500 people may die premature deaths annually due to this increase. The study envisages a trebling India's coal consumption from 660 million tonnes (MT) to 1800 MT a year. The study also outlines that enforcing the use of flue-gas desulfurisation (FGD) to scrub out the highly toxic sulphur during or after the burning of coal could bring down premature deaths by as much as 50 per cent annually. In monetary terms, utilising FGD technology could reduce health care related costs. But that it will also save thousands of lives across the country is perhaps a more urgent reason to consider its enforcement.

Source: Quartz India, December 9, 2014

Indian Railways transporting coal from the Jharia mines to iron and steel industries.

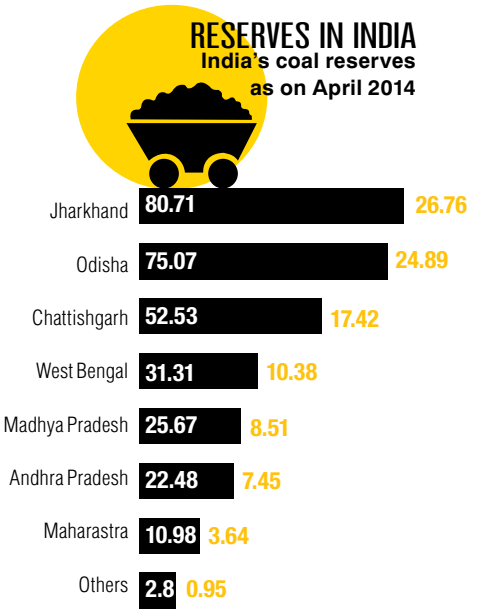
By **Staff Reporter**

The Coalgate Concern

Coal blocks were allotted to private companies for captive mining through a 1993 amendment to the Coal Mines Nationalisation Act (1973). However, the CAG found that the blocks were not allotted in a transparent manner, neither had the companies begun production.

India has one of the biggest coal reserves in the world, ranking only after China and the United States. As of April 1, 2014 India's reserves were estimated at a total of 301.56 billion tonnes by the Geological Survey of India (GSI). Of this, 'prime' coking coal stood at 5.313 billion tonnes, medium and semi-coking coals amounted to 28.76 billion tonnes, non-coking coals stood at 266 billion tonnes and tertiary coal at 1.49 billion tonnes.

More than half of India's commercial energy requirements are met by coal. As per the Coal Mines Nationalisation Act, 1973, coal belongs to the people of India, and the Government of India owns all the coal blocks. Coal mining thus could be done either by a governmental undertaking or any government company, that is, a company where the government has a 51 per cent share. However, an amendment in the Act in 1993, allowed coal blocks to be allotted to private companies for captive mining for power, steel and cement production.



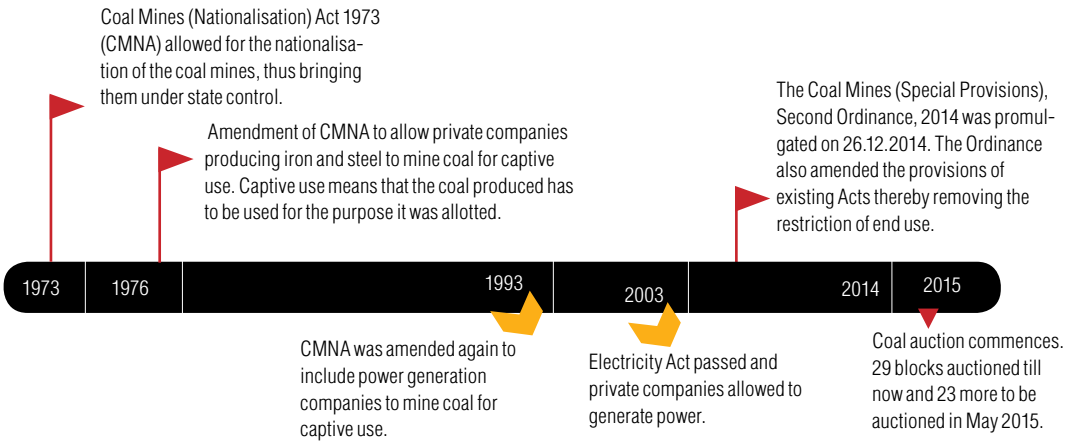
Figures in white: billion tonne.
Figures in yellow: Percentage of total reserves.
Source: Geological Survey of India.

Allocation of coal blocks

In June 2004, the Coal Ministry proposed that coal blocks which had thus far been allocated for free, be auctioned for the highest price possible. The Comptroller and Auditor General's (CAG),'Performance

PHOTO COURTESY: FLIKR@CREATIVECOMMONS-CRISPINSEMMENS

Fig.1: Coal Enactments Down the Ages



Audit of Allocation of Coal Blocks and Augmentation of Coal Production', Report No. 7 of 2012-13, found that the government had failed to introduce the auction route, though it could have done so as early as 2006, causing of approximately Rs 1.86 lakh crore loss to the public exchequer.

The Scam

The CAG further found that the allocation of coal-blocks to private players had been undertaken in a non-transparent manner. It also found that most companies had not begun production at all, and were in no hurry to do so, thus adversely affecting the availability of coal.

The Audit revealed that as of 2011, only 28 out of 86 coal blocks allotted had started production. Similarly, production from operational mines was only 34.64 million tonnes, when the targeted output was 73 million tonnes as per the CAG's Performance Audit. Very obviously, the private players had no incentive to begin production immediately, as they had received the coal blocks for free. In addition, the government had failed to enforce penalty for non-production.

Coal Auctions

Following the Supreme Court's decision to cancel the 204 coal blocks allocated between 1993 and 2009, the new National Democratic Alliance Government stepped in and sanctioned the Coal Mines (Special Provisions) Bill, 2015. The Bill consents commercial mining and auction of these ready-to-operate blocks.

The government also claimed that state governments stand to make humongous profit from the coal blocks auction—much more than the exchequer lost because of arbitrary distribution of blocks by the previous government. In a feature published on April 21, 2015, Business Standard claimed that according to their analysis, the auctions could fetch a potential revenue of INR 6,284 crores to the coal bearing states, once all the auctioned blocks begin production.

During the first round held between 14 and 22 February, the government successfully auctioned 19 blocks under the under Schedule II (already in production) class. The auction, however concluded with 15 blocks as four blocks came under the scanner for receiving low bids. Successful bidders included industry majors like Reliance Cement, GMR Chhattisgarh, Hindalco, Sunflag Iron and Steel, Jaiprakash Associates, Jaiprakash Power Ventures, OCL Iron and Steel, Bharat Aluminium, Essar Power MP, Jindal Power and UltraTech Cement. Round two was held between 4 and 9 May which resulted in the auctioning of 14 blocks (schedule III).

The government earned a whopping 4 lakh crores from the auction. Of the 33 blocks put up for auction, 29 have been successfully auctioned and another 38 allotted to state owned entities (Hindu Business Line, April 26, 2015). Coal secretary, Anil Swarup announced in a statement to the Press Trust of India on April 20, 2015 that the third round of bidding for 23 mines, shall commence from May 2015.

In the meantime, India's coal import statistics witnessed a massive 33.5 per cent increase in the last fiscal year. Official data enumerate that India imported 168.4 million tonnes in 2013/14, while mjunction, pioneers in e-auction services, put the figure at 181.58 million. The rise is due to fall in the international prices which experts colligate to lower purchases by China.

ANSWERS ON PAGE 46 »

Understanding coal: **India now ranks third amongst the coal producing countries in the world, with nearly 60 per cent of the India's total energy requirements are met from coal.**

1. Baghouses

a. A generic name for air pollution equipment which uses a range of filter bags/fabric types to separate particulate (dust, ash, powders, etc.) from the exhausting air stream.
b. Waste plant fibre left after the juices have been removed from sugar cane by crushing.
c. A casing containing thousands of long cloth bags used to remove Flyash from Flue Gas.

2. Boiler

a. A dispenser required to produce electrical energy.
b. A device found in power plants for generating steam for power, processing or heating purposes, or hot water supply.
c. A machine which helps in helps in avoiding emission of carbon dioxide in the air.

3. Clean Air Act

a. A federal law that defines EPA's responsibilities for protecting and improving the nation's air quality and the stratospheric ozone layer.
b. Law regarding availability based on unit outages and load reductions.
c. A treaty which includes restrictions on amount of power generation of non-renewable fuels.

4. Coal additive

a. A type of substance, either liquid, solid or gas, that is manually added to coal for some altering purpose.
b. A kind of material used to control the output of Generators connected to the electricity network.
c. A non-renewable resource obtained otherwise from natural means of production.

5. Combustion

a. The process of slowly turning the Turbine-Generator shaft to prevent bowing while it is still hot after shutdown
b. The process of retrieving energy from the burning of fuels in the most efficient way possible.
c. The process of designed to burn coal with little or fewer emissions possible.

6. Electronic Precipitator

a. A pollution control device that removes particles from a flowing gas (such as air) using the force of an induced electrostatic charge.
b. A machine which emits gaseous substance at standard conditions when fossil fuels are burned.
c. A device generating sufficient electrical power to drive pumps and fans on only one unit in the power station until it comes online..

7. Emission

a. The process of back-flushing with the help of compressed air.
b. Steam extracted from the Turbine to provide heat to the Feed water Heaters
c. Substances that are released into the air from power generating plants among other sources.

8. Flue Gas

a. Finely divided particles of ash entrained in gases resulting from the combustion of fuel.
b. Emissions from power plants and their by products form particulate matter, ozone smog and air toxins.
c. A combustible substance formed by the partial decomposition of vegetable matter without access to air.

9. Flyash

a. The combustion exhaust gas produced at power plants.
b. Finely divided particles of ash entrained in gases resulting from the combustion of fuel.
c. A major contributor of gastification plants which target synthetic oils and gases as end products.

10. Mercury

a. A metallic element that is toxic to human beings whose emission into the environment has come under increasingly tight restrictions.
b. Highly concentrated forms of far-ancient sunlight trapped in organic cells.
c. An analysis of coal based on removal of water and ash from the Coal sample.

[Coal Driven]

We will continue to depend on coal power, despite constraints in increasing coal production.

By **Abhijit Sarkar**

Coal dependency in India's energy needs

Domestic coal production has been falling behind demand. Allowing private merchant miners and removing the 'electricity' and 'non-electricity' differentiation could serve to strengthen the sector.

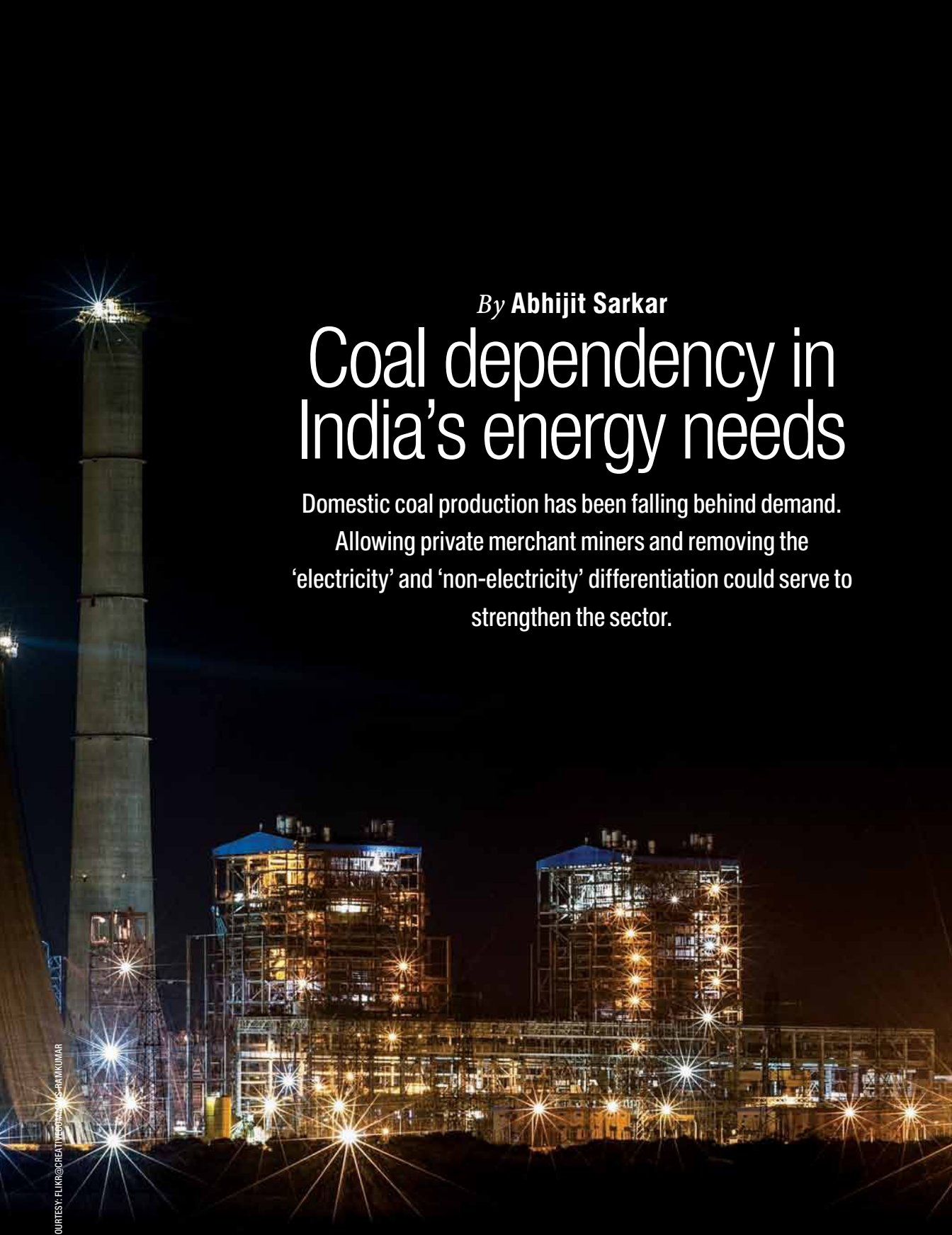


PHOTO COURTESY: FLIKR@CREATIVECOMMONS-RAMKUMAR

With a service sector-led economic growth, the energy intensity of the Indian economy has been on the decline at a pace faster than the rest of the world (figure 1). The decline, according to the Ministry of Statistics and Programme Implementation, 2015, Energy Statistics has been 1.3 per cent, as against -1 per cent the world over (https://yearbook.enerdata.net/energy-intensity-GDP-by-region.html).

Despite this, the overall demand for energy is expected to continue rising in the near future due to several factors, which include:

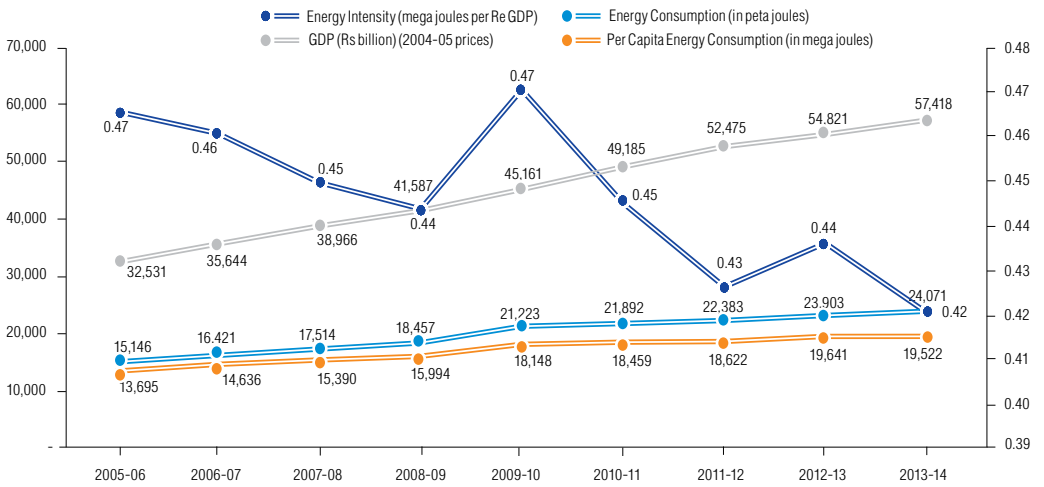
- The target of a 8.5 to 9 per cent annual growth in gross domestic product (GDP);
- The aim to increase the contribution of the manufacturing sector to 25 per cent of GDP by 2025 from the current 15 per cent;
- Increase in per capita usage of energy with greater economic prosperity and lifestyle changes;
- Expansion in the energy distribution network to cover larger populace.

As of now, coal remains the single major source of energy despite a declining share, and accounts for 41 per cent of all energy consumed in 2013-14. In fact, coal and crude petroleum accounted for 80 per cent of energy consumed in 2013-14 (figure 2).

The dependence on coal is revealed to be even higher if we focus on the capacity for electricity generation (table 1) and electricity production (figure 3). Almost 2/3rd of installed electricity generation capacity is coal based, and coal now accounts for almost 3/4th of electricity generated from conventional sources in India. In fact, after a two year fall in 2009-10 and 2010-11, the share of coal in electricity generation increased by 4.5 percentage points in the last four years. The left-over quarter is shared by petroleum (11.8 per cent), natural gas (10.2 per cent); and hydro and nuclear power (4.5 per cent). The continued dependence on coal is also reflected in the less than 2 per cent annual growth in electricity generation from petroleum and natural gas as against a 3.9 per cent growth in thermal power generation over 2005-06 to 2013-14. Though hydro and nuclear power generation grew at a marginally higher pace of 4 per cent over the period, it hardly had any impact considering their low base. This in itself will ensure our continued dependence on coal for many years to come despite constraints in increasing coal production or raising efficiency in thermal power generation or the initiatives taken to diversify and increase power generation from nuclear and other renewable sources.

Policy makers are well aware of the pitfalls in over dependence on thermal power, and have been pursuing several alternatives. Renewable energy sources including solar and wind energy, small hydro projects of up to 25 MW, biomass power, urban and industrial waste based power, have seen a 16 per cent per annum growth over the past 4 years, expanding from around 18,500 MW in June 2011 to 32,000 in January 2015, as per the statistics handed out by the Central Electricity Authority's various **reports on installed generation capacity.**

Fig. 1: Trends in GDP, Energy Consumption, Per Capita Energy Consumption and Energy Intensity



Source: Energy Statistics 2015, Ministry of Statistics and Programme Implementation.

Coal now accounts for **ALMOST THREE FOURTH** of the electricity generated from conventional sources in India.

Wind energy has emerged as the frontrunner among these, with installed capacity exceeding 22,600 MW as on February 2015, and estimated on-shore potential exceeding 1 lakh MW. Grid connected solar power also expanded from a miniscule 8 MW in January 2010 to 3,400 MW in February 2015, with targeted installation of 22,000 MW capacity by 2022 under the Jawaharlal Nehru National Solar Mission as per the Ministry of New and Renewable Energy's, Annual Report 2014 and Physical Progress Report 2015.

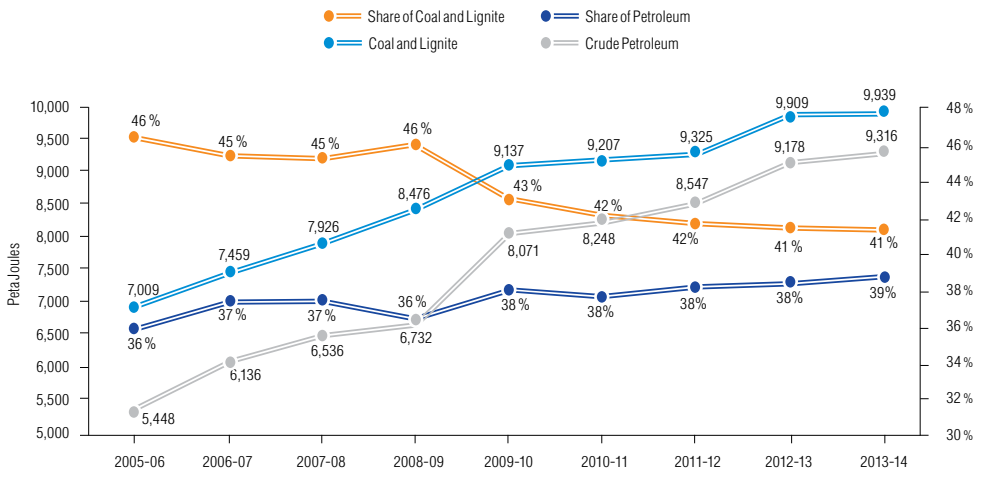
However, despite commendable expansion in renewable sources, the fast expanding demand for electricity will ensure continued dependence on coal, as reflected in the 2012 report of the Working Group on Power for Twelfth Plan, which shows an aggressive capacity expansion plan for the 12th (2012-17) and 13th plan periods (2017-22). In fact, planned capacity addition during the 12th plan works out to 95,485 MW. Despite the priority accorded to grid interactive renewable energy, hydro and nuclear generation under the Low Carbon Growth Strategy, the planned capacity addition from non-coal based sources will only be around 1/3rd at 32,790 MW.

One of the factors restricting the growth of non-coal based alternatives is the cost factor (table 2). Even the minimum tariff for wind energy at Rs 3.7 per unit is higher than the maximum tariff of Rs 3.2 per unit for pit head coal-based power stations. Similarly, tariff for solar power ranges from Rs 7.7 to 11.9 per unit. The estimated cost of nuclear energy is comparable to conventional sources, but expansion of nuclear generation capacity is unlikely in the face of considerable public opposition and investors dithering over disaster liability issues.

The projected expansion of thermal power generation during the 12th plan period implies an annual demand of 842 million tonne (MT) of coal for electricity generation, rising from 306 MT in 2005-06 to 427 MT in 2013-14. Apart from electricity, coal will also be in demand for the steel, sponge iron and cement sectors. Keeping in mind that the combined demand from these coal dependent sectors has grown at more than 4 per cent in the 2005-13 period, reaching around 600 MT by 2013-14, it is expected to cross 900 MT by 2016-17.

Despite this overwhelming dependence on coal, the 3.7 per cent growth in domestic coal production has been trailing behind demand due to policy and other bottlenecks such as non-operationalisation of captive mines, subsequent cancellation of coal block allocation, and non-receipt of environmental clearances. This has resulted in a steady increase in net imports from

Fig. 2: Energy Consumption and Dependence on Coal



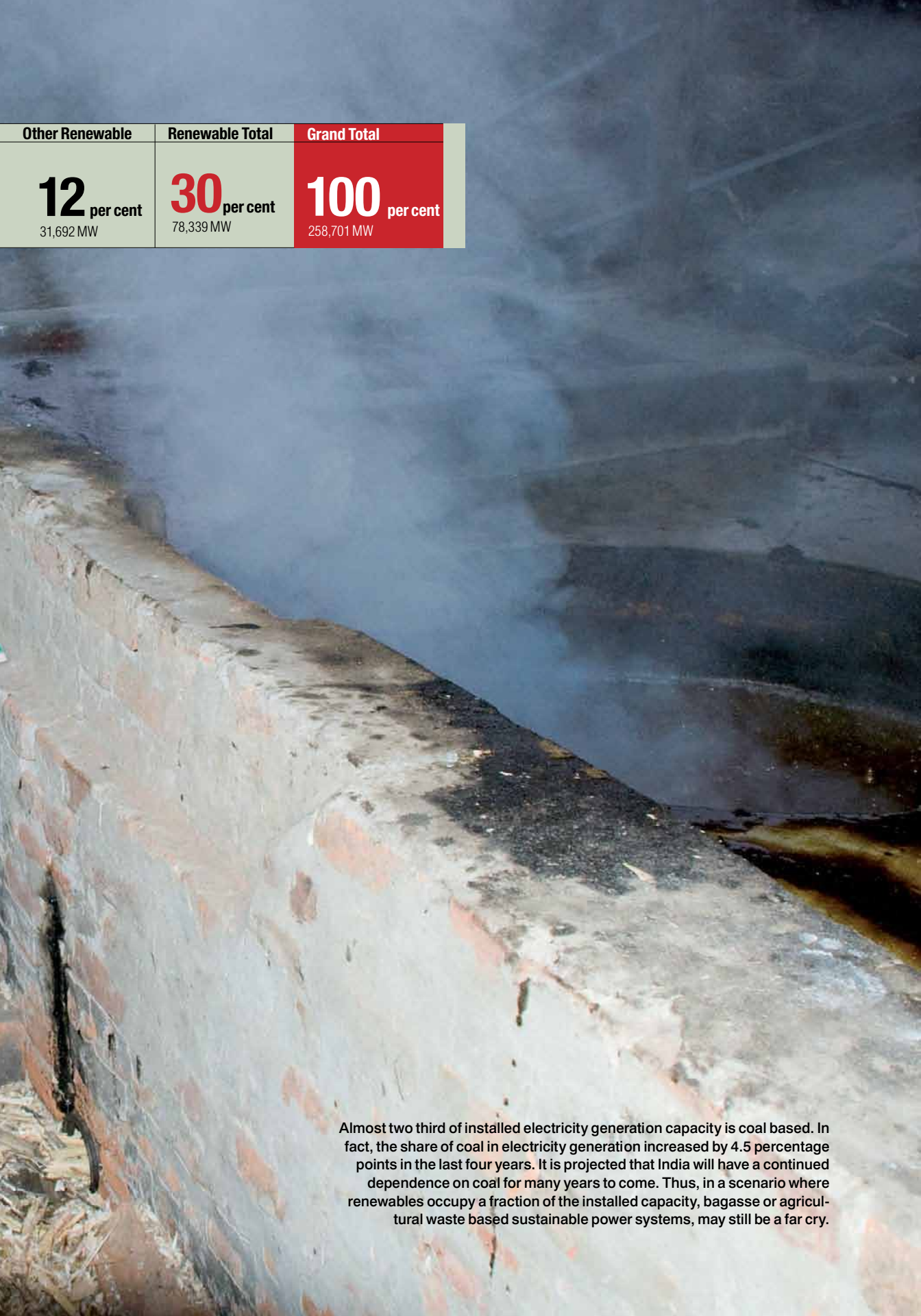
Source: Energy Statistics 2015, Ministry of Statistics and Programme Implementation.

Table 1: All India Installed Capacity of Power Stations as on January 31, 2015

Thermal				Nuclear	Hydro
Coal	Gas	Diesel	Total Thermal		
60 per cent 156,191 MW	9 per cent 22,971 MW	1 per cent 1,200 MW	70 per cent 180,362 MW	2 per cent 5,780 MW	16 per cent 40,867 MW

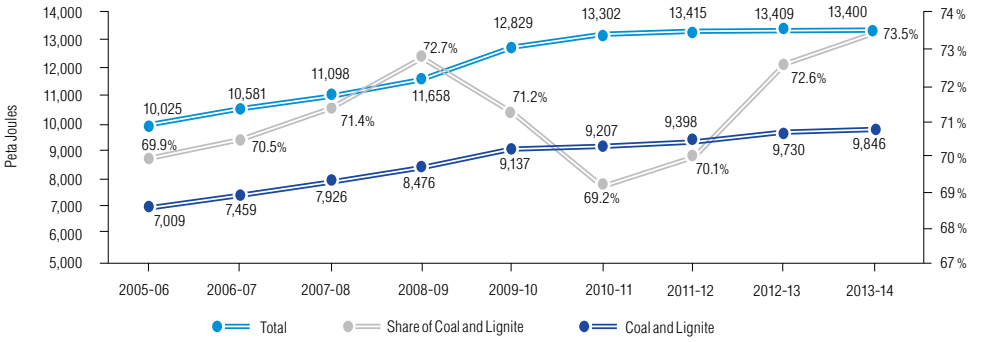
Figures in percentage indicate the category share in installed capacity under each category.
Figures in MW show the actual capacity per sector.
Source: All India Installed Generation Capacity Report, Central Electricity Authority.

Other Renewable	Renewable Total	Grand Total
12 per cent 31,692 MW	30 per cent 78,339 MW	100 per cent 258,701 MW



Almost two third of installed electricity generation capacity is coal based. In fact, the share of coal in electricity generation increased by 4.5 percentage points in the last four years. It is projected that India will have a continued dependence on coal for many years to come. Thus, in a scenario where renewables occupy a fraction of the installed capacity, bagasse or agricultural waste based sustainable power systems, may still be a far cry.

Fig. 3: Electricity Generation and Dependence on Coal



Source: Energy Statistics 2015, Ministry of Statistics and Programme Implementation.

Table 2: Minimum and maximum tariff for alternate power generation based on types of generating station

3.2 / 0.9 Pit-head coal based station	5.3 / 3.3 Non-pit-head coal based station	4 / 2.8 Lignite based station
4 / 2.7 Natural gas based station (APM gas)	4.5 / 4.2 Natural gas based station (NAPM gas)	10.7 / 8.4 LNG gas based station
13 / 7.7 Liquid based stations (Naphtha/HSD)	5.8 / 0.9 Hydro based station	6 / 3.7 Wind energy
7.7 / NA Solar PV (Photovoltaic)	11.9 / NA Solar CSP (Concentrated Solar Power)	3.4 / 1 Nuclear Energy

The figures are in Rs per unit; and, represent maximum (top figure) and minimum (bottom figure) total tariff in both fixed charge and energy charge.
Source: Response by Government of India to Unstarred Question No. 5072 in Lok Sabha on 13.08.2014

37 MT during 2005-06 to 166 MT during 2013-14. In 2015-16, power utilities alone will import around 73 MT of coal.

Overall domestic availability, though, is expected to improve with the successful auctioning of coal blocks. With companies now having to pay for coal blocks, they will have to operationalise mines at the earliest to recoup their investments. However, even though the auctioning system enhances transparency in the coal block allocation process, a few more steps are called for.

Firstly, the differentiation between coal blocks into those for electricity generation and non-electricity captive use allows for differential pricing, leaving scope for diversion of mined coal into non-intended use. This also limits the number of bidders per block.

Secondly, private participation is still limited to only captive users from the iron and steel, power and washeries sectors, with independent private merchant miners not being allowed. As a result, reliance on public sector behemoth Coal India continues despite its failures in raising production levels. In fact, in 2013-14, it could only meet 86 per cent of fuel supply agreement (FSA) commitment to power utilities (other than the National Thermal Power Corporation Limited), with production expected to touch merely 615 MT by 2016-17 from 482 MT in 2013-14.

Thus, to sustain India's long term economic growth by securing the country's energy needs, rapid expansion in coal production is needed, along with complementary enhancement of efficiency of the thermal power supply chain.

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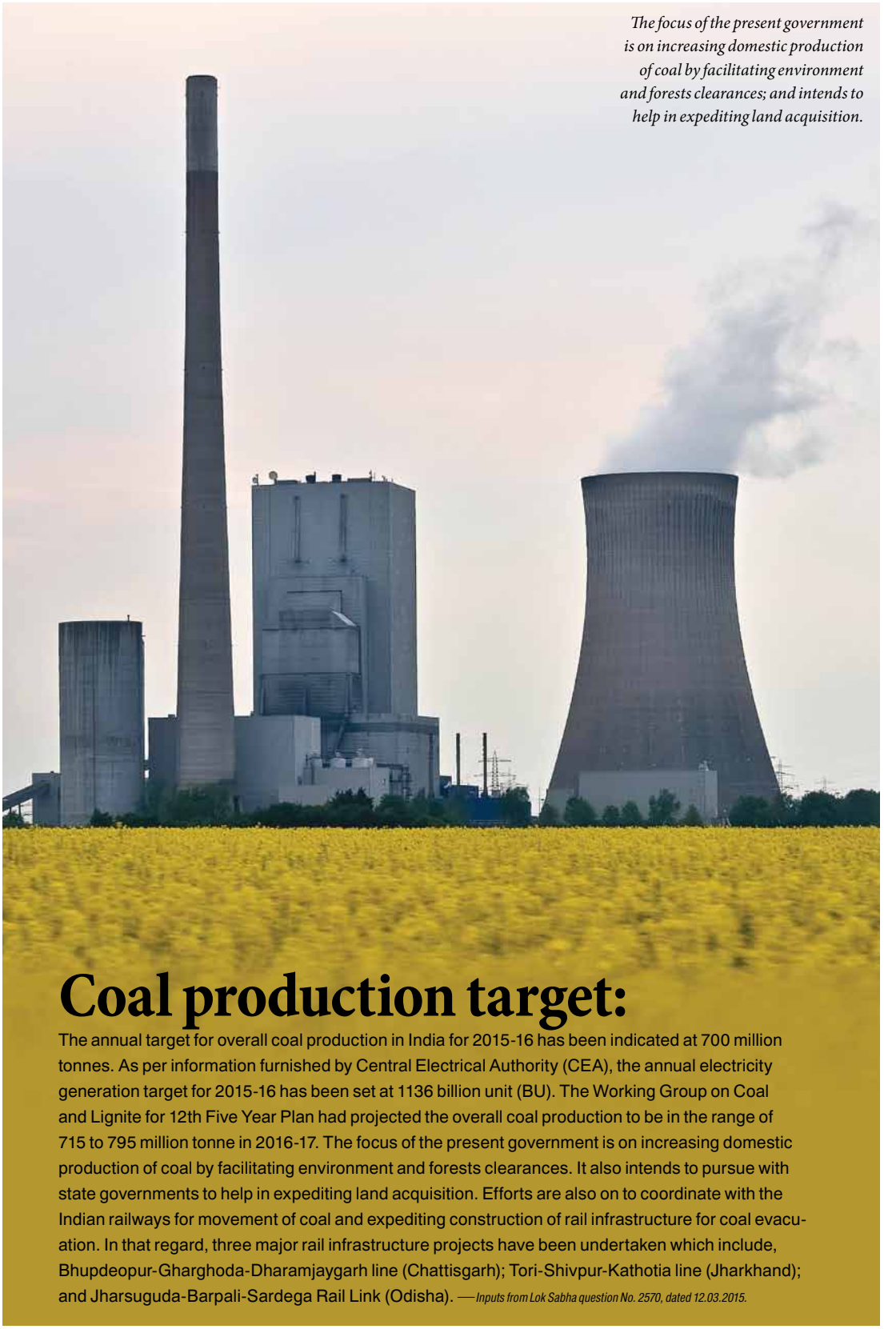

The focus of the present government is on increasing domestic production of coal by facilitating environment and forests clearances; and intends to help in expediting land acquisition.

Coal production target:

The annual target for overall coal production in India for 2015-16 has been indicated at 700 million tonnes. As per information furnished by Central Electrical Authority (CEA), the annual electricity generation target for 2015-16 has been set at 1136 billion unit (BU). The Working Group on Coal and Lignite for 12th Five Year Plan had projected the overall coal production to be in the range of 715 to 795 million tonne in 2016-17. The focus of the present government is on increasing domestic production of coal by facilitating environment and forests clearances. It also intends to pursue with state governments to help in expediting land acquisition. Efforts are also on to coordinate with the Indian railways for movement of coal and expediting construction of rail infrastructure for coal evacuation. In that regard, three major rail infrastructure projects have been undertaken which include, Bhupdeopur-Gharghoda-Dharamjaygarh line (Chattisgarh); Tori-Shivpur-Kathotia line (Jharkhand); and Jharsuguda-Barpali-Sardega Rail Link (Odisha). —*Inputs from Lok Sabha question No. 2570, dated 12.03.2015.*

PHOTO COURTESY: FLIKR@CREATIVECOMMONS-MARTIN

By **Rittwik Chatterjee** *and* **Srobonti Chattopadhyay**

COAL AUCTIONS IN INDIA

E-auctions can ensure transparency, prevent discrimination among buyers or favouritism, and let consumers have the coal of their choice.

Since the days of the industrial revolution, coal has played a crucial role in the development of industry. It has been a source for power generation as well as a critical input for many major industries. As one of the fastest growing economies in the world today, India is also largely dependent on coal for sustaining its expanding industrial structure. Coal is a critical input for power, steel and cement industries. It also continues to be the most dominant source of energy in India. Almost 52 per cent of primary energy needs in India are met by coal, while the world figure for the same is around 29 per cent. Coal contributes to around 60 per cent of India's

ILLUSTRATION: PRERONA MAJUMDER

Coal meets almost 12 per cent of India's primary energy needs.

power generation (All India Installed Generation Capacity Report, January 2015, Central Electricity Authority). Incidentally, India is the world's third largest coal producer, after China and the USA.

History of Coal Allocation Policies and Coal Auction

The Ministry of Coal under the Indian government is responsible for the development and exploitation, production, supply, distribution and pricing of coal and lignite reserves. Regulation of these activities is done through the government-owned Coal India Ltd., and the Neyveli Lignite Corporation. The Ministry also manages the government's 49 per cent equity participation in the joint venture public sector Singareni Collieries in Andhra Pradesh.

According to the July 1992 Comptroller and Auditor General of India (CAG) report, the Ministry of Coal issued instructions for constitution of a screening committee for looking into proposals received for captive mining by private power generation companies. However the report admits that there were no specific instructions given regarding the formal procedures to be followed for the allocation of coal mines. Hence, coal mines were allocated to applicants only on the basis of a letter of recommendation. Because of the absence of regulation, the Indian government subsequently constituted an expert committee for coal sector reforms. As per the recommendations of this expert committee, there were several modifications made regarding the guidelines for the allocation of coal blocks by the Ministry.

Even after the guidelines were put in place, the import of both coking and non-coking coal increased significantly between 2006 to 2011. In 2006-07 the import of coking gas and non-coking gas stood at INR 10181 crores and 6508 crores respectively, totalling INR 16687 crores. These increased to INR 20862 crores and 20688 crores respectively totalling INR 41550 crore by 2011 as per the draft CAG Report.

For this reason, the CAG undertook an audit on 'Allocation of coal blocks and augmentation of coal production' in 2012. The report suggested that the Indian government should finalise the regulations of competitive bidding, besides stating that "auctioning of blocks was considered the...acceptable selection process which was transparent and objective". By the end of 2014 the government decided to auction coal blocks during mid-February 2015, using the electronic auction (e-auction) method.

Benefits of E-Auction

Besides efficiency, promoting competition, and ensuring revenue maximisation, there are several benefits of using the e-auction mechanism for allocating coal blocks, as listed on the Coal India Limited website.

- Total transparency in coal marketing;
- Equal treatment to all categories of customers without any discrimination;
- Buyers getting coal of their choice in respect of source, grade, size/mode;
- Buyers can purchase coal from anywhere in the country;
- New consumers, snapped consumers and consumers seeking additional coal over and above their fuel supply agreement (FSA) quantity could buy coal under this scheme;
- Tendency of diverting coal to secondary market at a premium is greatly reduced, if not fully eliminated;
- No quota/linkage/sponsorship needed for purchase of coal;
- Option for depositing money for registration/ EMD online.

Tender Process for Coal Auction

According to the Ministry of Coal, coal mines are auctioned strictly for the utilisation of coal for specified end use. For the non power sector, the end use includes production of iron and steel, cement and generation of power for captive use for the non power sector, while for the power sector end-use is generation of power. Forward bidding (for unregulated sectors like steel, cement and captive power) and reverse bidding (for power generation) are the two prescribed methods for auctions. The tender process is conducted completely through electronic auction, on an electronic platform created by Metal Scrap Trade Corporation (MSTC) Limited, an enterprise of the Indian government; and, no physical bids are accepted or considered. Each bidder is required to pay a non refundable amount of Rs 5,00,000 as entry fee in order to participate in the auction. This applies to both the power and non power sectors. Upon payment of this entry fee, a bidder becomes eligible to download the tender document from the MSTC website. The tender process involves two stages. In the first stage, bidders are required to submit the bid security and the technical bid with a covering letter, along with the financial bid specifying the initial price offer, which cannot be less than the floor price.

The Supreme Court struck down the allocation of 204 coal mines **AFTER THE CAG FOUND THAT AWARDING THE MINES WITHOUT** an auction had cost the nation INR 1.86 trillion.

This floor price is pre-specified for individual coal mines. The nominated authority opens and evaluates the submitted bids and reserves the right to ask for any details, clarifications, or any other information in writing based on information provided by the bidders for evaluating technical bids or otherwise. The initial price offer of the bidders who meet the eligibility conditions, go through, and selection of technically qualified bidders involves ranking them on the basis of ascending and descending initial price bid submitted. The first fifty per cent of ranked or five technically qualified bidders, whichever is higher, are considered qualified bidders. In the event of qualified bidders being less than three, the concerned coal mine is subject to re-auction. The qualified bidder, who submits the lowest price offer during the e-auction, is the preferred bidder. Subject to the vesting order from the Indian government, the preferred bidder becomes the successful bidder.

Coal Auction 2015

In September 2014, the Supreme Court struck down the allocation of 204 coal mines after the CAG found that awarding the mines without an auction had cost the nation INR 1.86 trillion. The Indian government then initiated a coal auction in 2015. According to Power Minister Piyush Goyal (ndtv.com, March 10, 2015), the e-auction of 32 coal blocks, out of the 204 cancelled, "has already yielded potential e-auction revenues, royalties and up front payments of Rs 2.07 lakh crore, which is far in excess of CAG loss estimate of Rs 1.86 lakh crore."

The auction was divided into several phases. The first phrase held between February 14 and February 22 allocated 18 coal blocks. The auction in this phase saw aggressive bidding, with the exercise out performing all expectations. The winning bid of Rs 2,860 per tonne for the 29.2 million tonne (mt) Kathautia mine in Jharkhand, reserved for the so called unregulated sector which includes cement, aluminium, steel and iron came from Hindalco Industries Ltd. A day earlier, the winning bid of Rs 1,402 per tonne for 6 mt Sial Ghogri block in Madhya Pradesh, which was also reserved for the unregulated sector, was won by Reliance Cements Pvt. Ltd. The Belgaum block in Maharashtra was won by Sunflag Iron and Steel Co. Ltd with a winning bid of Rs 1,785 per tonne. The total revenue collected from these auctions was Rs 1.35 lakh crore (Economic Times, March 10, 2015).

The second phase of the auctions that started on March 4 involved the allocation of 16 coal mines. By closing hours of March 13, the revenue collected stood at more than 2 lakh crore. Hence, 34 coal mines were auctioned and allocated in these two phases. However, 8 coal blocks have yet to be allocated to successful bidders. According to the Ministry of Coal, these blocks had comparatively low bids and their re-allocation would require a re-examination by the nominated authority.

Out of 43 coal blocks allotted to government companies, 42 blocks are meant for end use by the power sector. However, there has been no bidding for the allotment of these blocks, and hence, no apparent cut in power tariff. But, lower costs of coal could help companies keep their power rates low. Owing to stiff competition, the reserve price, which was to act as a ceiling was fixed as zero by the government. For every Rs 100 fall in the bid amount, the power rate falls by six paise.

Endnote

Auction as a method of allocation has been in use for many years and still holds relevance in terms of efficiency and transparency. Since coal is a crucial resource, its allocation is also of crucial importance. Coal auctions done transparently can generate a good amount of revenue for the government. Hence, auctions can prove a reliable method for allocating coal mining rights. Although some analysts opine that aggressive bidding by companies may hike the prices for cement, steel and sponge iron—electricity tariffs are unlikely to increase as mines for these sector are auctioned through reverse bidding, where the lowest bidder wins the auction. GY

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By **Nitya Nanda** *and* **Saswata Chaudhury**

Coal based economy for India post 2030

Coking coal being produced in the Cherrapunji area of Meghalaya. Lignite, belonging to the tertiary deposits, is primarily found in this region.

Abundant and cheap availability of domestic coal led India to follow a coal centric development path in the past. Given the current trends in production and consumption, India is expected to exhaust its coal reserves within the next four decades.

PRAVEEN NEGI

Coal is the second largest source of energy worldwide, after mineral oil. In India, more than 80 per cent of thermal power generated is coal based. As per most projections, this coal-centric energy structure may continue for at least the next couple of decades.

India is a leading coal producer, consumer and importer. Indian coal consumption has increased from 411 million tonnes in 2001 to 793 million tonnes in 2013 and shows an increasing trend. In spite of increased domestic production (from 452 million tonnes in 2007 to 613 million tonnes in 2013), coal import has increased (from 54 million tonnes in 2007 to 180 million tonnes in 2013, of which 142 million tonnes were of the steam coal variety), as per the statistics made available on http.://www.worldcoal.org. This is partly due to the increasing gap between production and consumption as well as the low quality of domestic coal.

In the past, India's dependence on coal was mainly due to the abundant availability of coal and low cost of recovery. This saw Indian power generation being generally coal based. In the current context when coal is neither cheap nor domestically abundant (in good quality), relying on coal becomes questionable. Apart from these, there are social and environmental issues related to thermal power. Besides, given the current trends in production and consumption, India is expected to exhaust its coal reserves within the next four decades.

The increasing trend of resource nationalism and export restrictive measures in countries exporting coal and global price hikes make the situation even more problematic. It may hence, prove difficult to continue with coal-centric development, in spite of coal remaining an important source of energy in the near future. Thus, India will need to strategise and reduce its dependence on coal through diversification of its energy basket.

Environmental and Social Challenges

Unless carefully planned and controlled, coal mining can take a huge toll on the environment. The different stages of coal mining and cleaning, ranging from transportation to electricity generation to mine closure, can play havoc on the environment, directly or indirectly. Major environmental challenges related to coal mining include emission of SOx, NOx, CO, CO_2 and other harmful gases, destruction of forest and biodiversity, release of particulate matter and dusts, besides land degradation and subsidence.

In India, most coal reserves are concentrated within forests and river basins inhabited by indigenous communities or are densely populated. Any mining activity hence, involves large scale relocation and loss of livelihood for indigenous populations, apart from destruction of natural resources. Since opencast mining is widespread in India, the corresponding socio-environmental costs are high.

As compared to underground mining, opencast mines require large tracts of land and can result in significant loss of habitat and livelihood. Mining-induced displacement has increased significantly since the 1970s as the country's coal production has shifted from underground to opencast. The Ministry of Coal estimates that a minimum of 1, 70, 000 families, involving over 8, 50, 000 people would be affected by future coal projects, as per its Coal Vision 2025 report, compiled in 2005.

Workers engaged in coal production at the mining, processing and burning stages are exposed to several risks and health hazards, including inhalation of crystalline silica dust during highwall drilling and mining that can lead to black lung disease, inhalation of toxic fumes and gases and exposure to ultraviolet and infrared radiation at welding operations, as also noise-induced hearing loss due to prolonged exposure to processing and mining equipment; besides heat stroke and exhaustion.

In view of the issues involved, we need to urgently implement measures to increase production efficiency. This can be done by firstly, extracting more coal from existing reserves and, secondly, producing more energy from the same amount of coal.

Technology Options

These dual objectives can be achieved by employing clean coal technologies (CCTs) that can reduce emissions upstream, downstream, or within the power generation (energy conversion) process. CCTs need to be used right from the coal mining stage. A shift from opencast mining to underground mining using efficient technology and internationally acknowledged improved practices not only minimises land degradation and pollution of water and air, but can vastly reduce the displacement of people. Adoption

of suitable technologies can, hence, result in reduced particulate and greenhouse gas emissions along with efficiency gains at the combustion stage, as pointed out by N Nanda, in his paper, 'The potentials of clean coal technologies in promoting energy security in India', presented at the World Clean Coal Conference in New Delhi, held in February, 2015.

However, there are several challenges in implementing these technologies in India. They include patent restrictions, insufficient adaptation of technologies to local conditions, shortage of trained manpower, absence of relevant institutions and mechanisms, high capital investment, and lack of government incentives and enabling policies. The government, though, is currently taking initiatives to introduce CCT in India through various research and development programmes, demonstration plants, and pilot studies. Foreign collaborations at the governmental level can increase access to these technologies. Besides, India has also launched the national mission on clean coal technologies under its National Action Plan on Climate Change (NAPCC).

Even if the idea of CCTs is relatively new, India has been leaning towards similar policies since the '80s. Underground coal gasification (UCG) had been adopted several decades ago by the Oil and Natural Gas Commission (ONGC) and Coal India Limited (CIL), with technical assistance from the then USSR. Unfortunately, although UCG was found to be technologically feasible in one block, little progress was achieved due to other considerations. Similarly, Oil India Limited (OIL). had undertaken test work, pilot plant runs and feasibility studies on underground coal liquefaction (UCL) using direct liquefaction technology from the USA. But relatively high costs prevented commercial operations.

Potential Future Scenario

Currently, India is extracting coal through opencast and underground mining. However, about 90 per cent of the coal in India is opencast, with the depth normally never beyond 60 m. Though there are mines in India that extract coal from 600 to 1200 m, such as those in Moonidih and Chinakuri, they are few and contribute a very insignificant percentage to total coal production. In underground mines, the depth is generally never beyond 300 m. Since expansion in the last few years has been through the opencast mode, India is fast depleting its reserves.

As on 01.04.2014, Indian coal reserves (including proved, indicated and inferred) were estimated at 301 billion tonne (267 in 2009), of which 266 billion tonnes comprised the steam coal variety. Of the total steam coal reserves, more than one-third is available at a depth of more than 300 m. These include coal lying beneath villages and towns, sanctuaries/forests, rivers, water bodies and the like, as also coal already extracted. The exact figure for extractable coal reserves in India remains unknown, but the Central Mine Planning and Design Institute (CMPDI) broadly assesses it to be 52 billion tonnes.

Through gasification technology, it is possible to access coal up to a depth of 1.5 km . The range may increase in future, and may address both energy security and environmental concerns. Such technologies also help access reserves using much less land; this might prove a boon with lands becoming difficult to acquire in recent times.

On the other hand, technologies like carbon capture and storage (CCS) might prove inappropriate in the Indian context, since CCS not only gives less energy per unit of coal but also requires more land.

Each of these low pollution technologies are usually less labour-intensive. However, while shifting from opencast to underground mining reduces pollution, it increases labour intensity as well. Complementary technologies like UCG or UCL are, on the other hand, are less labour intensive. Thus the combined effect of both is not easy to predict.

In the near future, as India moves on to more renewable power options, our dependence on coal is bound to reduce. But the high investments on green power do not guarantee instant solutions. Hence, if we must continue our dependence on coal-centric development, it is important to explore more efficient and less polluting technologies. In that context, the country may need to confront a trade-off between fewer jobs and environmental concerns.

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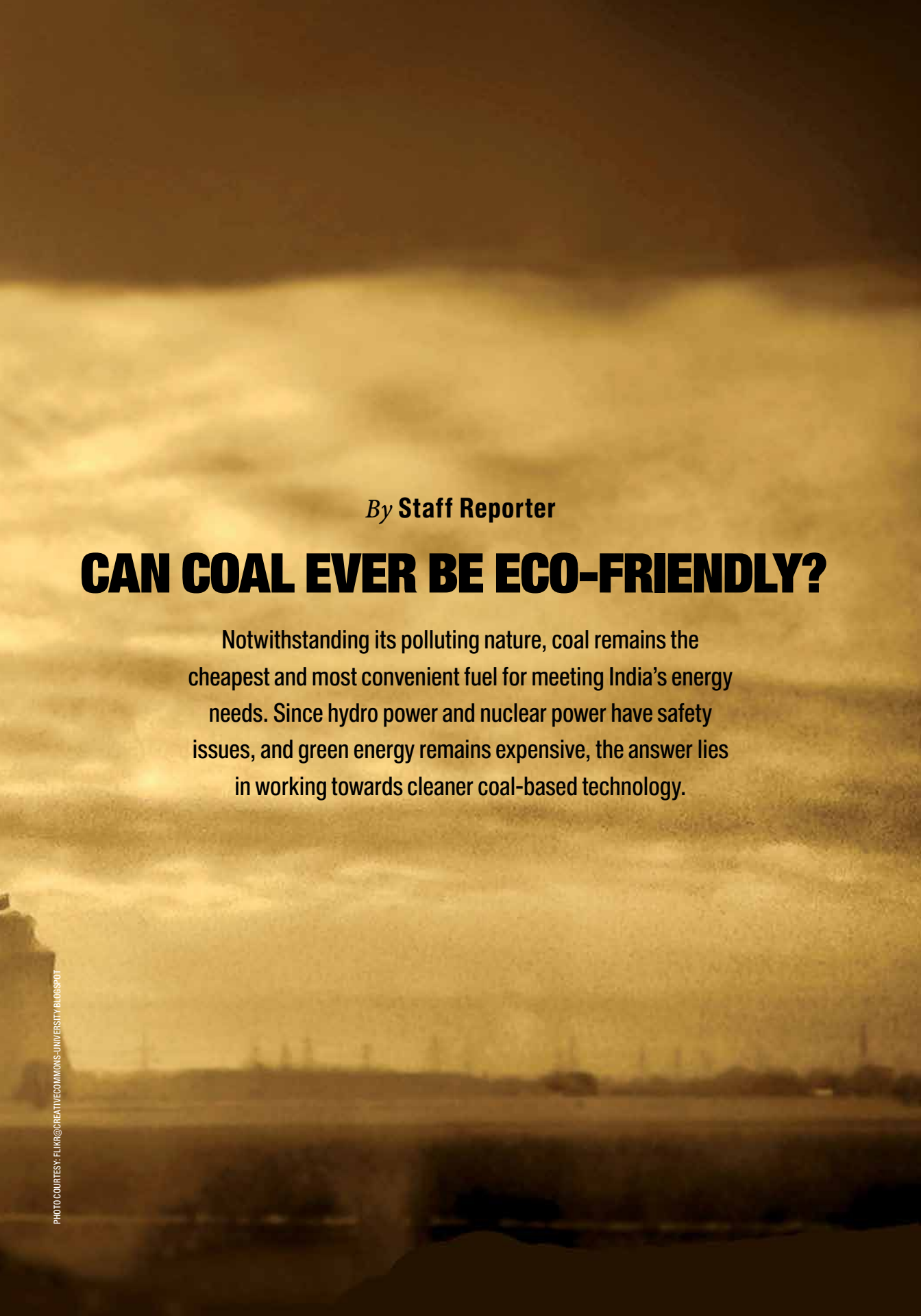
The views in the article are solely of the authors and does not reflect the views of TERI.

Coal-to-liquid technology offers a range of important environment friendly synthetic fuels and products produced by liquefying coal.



By **Staff Reporter**

CAN COAL EVER BE ECO-FRIENDLY?

Notwithstanding its polluting nature, coal remains the cheapest and most convenient fuel for meeting India's energy needs. Since hydro power and nuclear power have safety issues, and green energy remains expensive, the answer lies in working towards cleaner coal-based technology.

PHOTO COURTESY: FLIKR@CREATIVECOMMONS-UNIVERSITY BLOGSPOT

Mining of coal is one of the most destructive activity for the environment. Whatever the method of mining be—opencast or underground, green fields and forests cannot remain untouched. Since one has to rip off the surface layer to gain access beneath, a cavity results during and after mining. When monsoon rains fill these up, the waters percolate through resulting in land subsidence. Moreover, when there is underground mining, once the coal is exhausted and supports withdrawn, the soil caves in causing a depression. Mining often changes the hydrological regime of regions, affecting the courses of local streams and minor rivers. Underground mining can extend up to aquifers and can hamper their normal functions, thus causing ponds to dry up and rivers to divert. Topographical changes, landslides, loss of valuable agricultural land and lush vegetation are all a part and parcel of the mining process. Additionally, mining of coal exposes the region to the danger of devastating coal seam fires, sometimes naturally through spontaneous combustion caused by the friction between gases in mines, and at others, induced by man.

Coal Mine Hazards

Firedamp present in mines containing bituminous coal have been historically known to cause explosions and hence, miners' deaths. Firedamp is the name given to the group of inflammable hydrocarbons, prominently comprising methane, found in mines Firedamp accumulates in pockets in the coal and adjacent strata, and when penetrated, can trigger explosions. Variations of firedamp are 'black damp' which is a mix of carbon dioxide and nitrogen caused by corrosion, 'after damp' which includes the same gases as a black damp, plus carbon monoxide, and 'stink damp', which reeks of rotten eggs, and is mostly hydrogen sulphide. Each of these can explode and cause accidental deaths. 'White damp', is another major variation which is totally indiscernible since it lacks a scent, but contains carbon monoxide, and can be toxic at even low concentrations, causing death.

At times, digging for coal can result in a wrong blow hitting a groundwater aquifer. This results in the punctured water table giving way, flooding the mine and killing thousands at one go.

Even otherwise, dusts in mines have a high amount of suspended particulate matter (SPM), which, along with other gaseous hydrocarbons, especially methane and ethane, make a volatile composition. This exposes miners to the risk of respiratory and bronchial ailments, as also cancer.

Coal Processing

The processing of coal is another very polluting affair. After being mined, coal requires to be washed with water sourced from rivers, ponds, or lakes. The water that flows into the washeries and the water that flows out are vastly different in composition. Apart from the dust and the grime which covers coal, several other chemicals invisible to the eye dissolve in the water. Sulphates of ammonia, sulphur dioxide, carbon monoxide, methane and various other hydrocarbons are released from the washeries into local water sources. Consequently, Damodar, which flows through the coal producing Chhotanagpur plateau spread over Jharkhand and West Bengal, is one of the most polluted rivers in India.

If mining is not done scientifically, or safety measures ignored, coal seam fires can result. Once ignited such a fire can burn for decades or centuries, until the entire coal reserve is exhausted. Such a fire remains unmonitored and can be extremely dangerous. It can cause land subsidence and kill by suffocation and exposure to toxic gases. In the Indian context pollution from burning coal has become a matter of grave concern. Thermal power plants are the main source of such pollution as 80 per cent of the power generated by India's thermal power plants is coal-based.

After being treated in washeries, the coal is readied for use in the power, and other sectors. The combustion of coal, particularly in thermal power, results in four major components being emitted—SOx, NOx, suspended particulate matter and carbon monoxide.

Flyash, which is generated on combustion of coal, is a major source of worry, particularly since Indian coal has more than 45 per cent ash content. At the moment, India's coal based thermal power plants produce more than 112 million tonnes of flyash, for which 65000 acres is being used for dumping. By 2017, the amount of flyash is expected to cross 225 million tonnes.

I Nawaz, in an article, 'Disposal and utilisation of flyash to protect the environment', in the International Journal of Innovative Research in Science, Engineering and Technology, (October

2013), points out, "When pulverized coal is burnt to generate heat, the residue contains 80 per cent flyash and 20 per cent bottom ash". Being just 0.5 -300 micron in diameter, and lightweight flyash particles are easily airborne and can hence pollute the environment.

Flyash dumps are always lined in the US, and kept moist. Since such lining is not done in India, flyash can seep through and severely pollute water by blocking the air spaces in the soil apart from causing siltation. Flyash turns soils acidic, and can mar soil fertility. It also interferes with the photosysnthesis of aquatic plants, and affects the food chain.

The Central Electricity Authority (CEA) which manages thermal power plants has issued directives for 100 per cent utilisation of flyash through recycling and other uses. However, it recently took several defaulting power plants to task for not having done so.

Tackling Flyash through Technology

For several years, flyash has been used as landfills. Of late, flyash bricks are becoming popular as a building material. This technology, developed by Indian Institute of Technology (IIT), Delhi, involves replacing flyash for cement in mortar. Flyash bricks have been successfully used for the construction of roads and embankments in the country and the technology is gaining ground.

The Energy Research Institute (TERI) has proven that flyash dumps can be reclaimed by adding organic matter and symbiotic fungi, making them commercially viable for floriculture and silviculture. An ash pond at the Badarpur Thermal Power Station has been reclaimed using mycorrhizal fungi based organic biofertilizer. As the fungus germinates, it sustains the partner plant and quickly spreads to the roots and beyond, improving the plant's water and nutrient intake, storing carbohydrates and oils for use when needed, protecting the plant from disease, and detoxifying contaminated soils. This keeps both air and water pollution under control. The demonstration site at the Badarpur power station now grows marigold, tuberose, gladioli, sunflower, and carnations apart from trees such as Indian rosewood, poplar and eucalyptus.

Being rich in oxides, flyash has been found suitable for agricultural applications as well, and is fast gaining acceptability among farmers.

The National Thermal Power Corporation (NTPC) has also developed a dry ash technology, wherein flyash is collected in huge mounds, and a filter bed is provided at the bottom (of each mound). Grass is then planted on the slopes of the mounds and a polymer layering is provided to prevent the ash from being blown off by the wind. Flyash thus treated develops certain physical properties that make it more suitable for commercial use.

Flyash can **POLLUTE WATER. IT CAN TURN SOILS ACIDIC** and cause siltation; it can thus affect the food chain.

Liquid Coal vs Petroleum

Coal-to-liquid (CTL) technology or the 'Fischer-Tropsch' technology offers a range of important environment friendly synthetic fuels and products produced by liquefying coal.

The technology was first developed in the 1920's by German scientists at the Kaiser Wilhelm Institute. The process became known as 'Fischer-Tropsch Synthesis' after its creators, chemists Franz Fischer and Hans Tropsch. During World War II, Fischer-Tropsch fuels were used to power planes and tanks for the German army.

In this method, coal is fed into a gasifier. Within the gasifier, controlled amounts of heat, pressure and oxygen are added to break up the molecular structure of the coal. The gasifier only allows a portion of the coal to burn, resulting in the partial oxidation of the coal. This reaction produces carbon monoxide and hydrogen rich synthesis gas.

Synthesis gas, or syngas, is then fed into a reactor where it is condensed over a catalyst, which is typically iron or cobalt. The exposure to the catalyst converts the syngas into liquid and wax products that can be refined into synthetic fuels.

CTL fuels can be used to run a variety of vehicles including cars, trucks, tanks and jets, while the waxes produced may be stored indefinitely. Depending on the catalyst and conditions in the reactor, CTL products vary in density, composition and prospective use. Excess steam from the gasification process can be used to produce electricity.

With CTL technology, emissions are removed before the fuel is burned. Because coal gasification uses oxygen rather than air to produce syngas, the

The combustion of coal, particularly in thermal power, results in four major components being emitted—SOx, NOx, suspended particulate matter and carbon monoxide. Flyash, which is also generated is a major source of worry as it has many detrimental environmental repercussions.

resulting gas stream is smaller, and emissions from it can be stripped off easily and efficiently. Hence, the resulting fuel products are clean. CTL diesel, for example, is sulphur free.

At the moment, scientists are trying to limit the production of carbon dioxide, which is released when the coal is liquefied and again, when CTL fuel is burned. There are several methods of carbon dioxide capture and sequestration that are under development. These processes and technologies would capture and condense carbon dioxide during coal gasification, and then store it safely in underground structures such as saline aquifers. The captured carbon dioxide could then be sold to oil companies to increase oil field yield by injecting it into depleted oil wells. However, building a CTL plants can cost billions of dollars, and investors are not yet forthcoming.

Central Mine Planning and Design Institute (CMPDI) is planning to put its first coal-to-liquid research project in Digwadi, Dhanbad, by August 2015, in collaboration with Central Institute of Mines and Fuel Research. Speaking with the G'nY correspondent, Prabhat Shanker, General Manager, CMPDI said, "our research is focussed on finding the right catalyst for India's bituminous, so that the process is extremely cost effective." He claims that once the breakthrough is made and costs ascertained, not only will petroleum become easily accessible and perhaps cheaper, but it will also reduce the environmental repercussions of burning coal. The future, thus, could prove bright for this technology which is being seen as the best modification to a polluting, but indispensable fossil fuel.

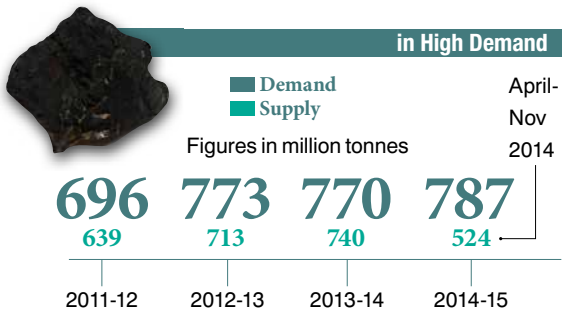
Endnote

Notwithstanding its polluting nature and processes involved, coal remains the cheapest and most abundant fuel for meeting India's energy needs. Although the government has been exploring alternatives such as renewable sources to produce green energy, these are still expensive. At the same time, hydroelectricity and nuclear power have environmental and safety aspects that are difficult to ignore. The answer hence, lies, in working towards cleaner coal-based technology to minimise health hazards from the processes involved in mining and processing coal for thermal power generation.

PHOTO COURTESY: FLIKR@CREATIVECOMMONS-MONICA MCGIVERN

Snippets on Coal

The demand-supply gap: The all India demand for coal has been increasing consistently through the last four years. The supply, both from domestic sources as well as imports have fallen short of the requirement. The global prices for coal have declined during 2013 and 2014. A case in point is the data published in the World Bank's Pink Sheets, where the price of Australian thermal coal which was 92.77 USD/MT in January, 2013, was revealed to decline to 62.44 USD/MT in December, 2014. This decline may have affected the auctioning of coal blocks in the nation as the auction process is market driven.



—Inputs from Lok Sabha question no. 1638, dated 5.03.2015.

Harnessing methane: In order to harness coal bed methane (CBM) potential in the country, the Government of India had formulated a policy in 1997 wherein CBM is explored and exploited under the provisions of Oil fields (Regulation & Development) Act 1948 and Petroleum and Natural Gas Rules, 1959 and administered by Ministry of Petroleum & Natural Gas. As an ongoing process, Directorate General of Hydrocarbons carries out studies to shortlist and carve more CBM blocks for auction for the forthcoming CBM rounds in consultation with Central Mine Planning & Design Institute Ltd. and Ministry of Coal. As on date, 33 CBM blocks have been awarded to various public sector undertakings/private organisations in four rounds of bidding for exploration and exploitation of CBM, which covers 17,200 sq km (66 per cent) of the total available coal bearing area (26,000 sq km) in 11 states of India viz. Andhra Pradesh, Chhattisgarh, Gujarat, Jharkhand, Madhya Pradesh, Maharashtra, Assam, Odisha, Rajasthan, Tamil Nadu and West Bengal. Total prognosticated CBM resource for 33 awarded CBM blocks is about 63.3 trillion cubic feet (TCF), of which so far, 9.9 TCF has been established as gas-in-place from 8 CBM blocks that have entered the development phase.

—Inputs from Rajya Sabha question 1121, 09.03.2015.

By **Rina Mukherji**

COAL SEAM FIRES

Once a coal seam catches fire, it may continue to burn for thousands of years.

People are beginning to shun matrimonial alliances from affected areas of Jharia.

In India, coal is the most important and abundant source of energy. India is the world's 3rd largest coal producer, after China and the US. Most significantly, over 60 per cent of India's power generation is coal based (Central Electricity Authority, June 2014). However, not only is coal a polluting source of energy, but underground coal fires, or coal seam fires, can be a major source of greenhouse gases, as the Intergovernmental Panel on Climate Change (IPCC) has pointed out in its Fifth Assessment Report.

Coal seam fires can be due to natural or man-made causes. Once a coal seam catches fire, it may continue to burn for tens and thousands of years, depending on the availability of coal and oxygen. The world's oldest such fire has been going on for the last 6000 years in Australia. There is another fire in Germany, which is on since 1630. In recent years, a major coal seam fire accidentally ignited in 1962 in Centralia, Pennsylvania, US, has been smouldering for over 50 years.

History and Causes

Man-made fires are the result of opencast, or surface mining, and wrong practices. Unscientific mining resulting in insufficient ventilation of mine shafts, as also bad lighting systems that spray sparks may cause fires. In other cases, human induced fires may

be the result of sheer carelessness. For instance, in India, illegal distillation of alcohol in coal mining belts often induces coal seam fires. One of the oldest raging fires in the US was started due to burning of trash in 1962 by residents over an abandoned coal strip mine being used as a dump in Centralia, Pennsylvania. The residents did not realise that the mine had not been properly sealed; besides, the dump had a 15 foot long opening that connected to a maze of underground mine tunnels. These passages allowed the fire to spread to the coal seam underneath the town, and saw it expand along four fronts, eventually affecting a surface area two miles long and three quarters of a mile wide. Despite over 4 million USD being spent to control it, the Centralia fire continues to burn to this day.

In India, the coal seam fires that we know of, in Jharia and in Raniganj, are man-made fires that are a result of unscientific mining and greed.

Jharia coalfield in Dhanbad district in Jharkhand is a major source of coking coal in the country. Opencast mining in the Jharia coalfields started in 1894 and intensified around 1925. The only remaining reserve of prime coking coal in India, and covering 450 square km, the Jharia coalfields abound in bands of coarse to medium grey and white sandstones, shales and coal seams, called the Barakar formation.

It was in 1916 that the first coal seam fire was detected in Jharia. In 1930, the coalfields saw such a devastating fire that the resulting land subsidence led to the total destruction of the bungalow above it. Since then, several major and minor fires have become the bane of this mining town.

Jharia has 23 large underground and nine large opencast mines. Interestingly, one often sees individuals shovel up coal from alongside roads or railway tracks, around homes or even farms. This leaves the coal seam exposed to the atmosphere, and in danger of catching fire. Coal with high ash content, as is common with the Indian variety, is always more susceptible to fires.

An 2013 article by A Mohan Ram *et.al.*, 'A brief review on the status of coal fire in India', published in the International Journal of Environmental Biology in 2013, has listed geological factors (seam thickness, seam gradient, caving characteristics, faulting, coal out-bursts, friability, rider seams, depth of cover, geo-thermic gradient); mining factors (mining methods, rate of advance, pillar conditions, roof conditions, packing, leakage, multi-seam working heat from machines, ventilation pressure differential, barometric pressure, changes in humidity); and seam factors (petrographic composition, temperature, available air, particle size, moisture, sulphur, interfering minerals, physical properties, effect of previous oxidation, heat due to earth movement, bacterial effect) as contributing to the occurrence of coal seam fires in a region.

In their opinion, working at shallow depths, thick seam mining and multi-seam contiguous panel working, not only initiated the start of the fires but also sped up their spread in the Jharia and Raniganj coalfields of eastern India. In addition to these, unscientific mining has taken a major toll of the reserves too.

Once a fire breaks out in a coal seam, large cracks that serve as channels to carry oxygen underground serve to fan the flames. As the burned coal turns into ash, the rock overburden can no longer be supported and deep cracks open up. Eventually the surface collapses causing extensive damage. Although the coalfields are now operated by the Bharat Coking Coal Limited (BCCL) since nationalisation in the'70s, the fires continue to rage to this day, taking their toll on livelihoods, vegetation, land, roads and all that make up a well-knit community.

Jharia has today ended up as one of the densest concentration of fires in the world, with 68 coal seam fires concentrated within a 174 square mile region as pointed out by Discover magazine in an article, 'Earth on fire', in its 2010 July-August issue. Another study on the Jharia coalfields and the effects of underground fires therein, 'Monitoring subsurface coal fires in Jharia coalfield using observations of land subsidence from differential interferometric synthetic aperture radar (DInSAR)' by Nishant Gupta *et. al.*, of the Indian school of Mines, Dhanbad, revealed that the fires had resulted in major subsidence in the eastern and western flanks of the coalfield.

In Raniganj, the fires detected are probably due to infection from adjoining coal seams in Jharia that are now on fire. Although the fires are not as widespread or as threatening, Tapas Ranjan Maitra *et al.*, of the Geosciences Group, National Remote Sensing Agency, in a 2005 article, 'Coal-fire detection and monitoring in Raniganj coalfield, India—A remote sensing approach', published in Current Science has warned that lack of a monitoring mechanism is sure to escalate the situation.

Environmental toll of Coal Seam Fires

Economically, a coal seam fire is a major disaster, since it results in the destruction of thousands of tonnes of valuable coal. But then, there are social and environmental consequences as well. Most significantly, it is a major source of greenhouse emissions, and hence global warming.

Coal seam fires leak noxious carbon monoxide, mercury and sulphur dioxide that can have long term effects on human health, besides creating sinkholes. According to a paper, 'Coal fires burning out of control around the world: Thermodynamic recipe for environmental catastrophe', published in the International Journal of Coal Geology in 2004, some of the sulphur released in Centralia crystallized and stayed on the ground, potentially tainting local water, with the rest floating into the atmosphere, thus polluting the air breathed.

Unlike coal burnt in a power plant, which is monitored and supplied with oxygen so as to burn less by-products, coal burning in an abandoned mine, gets far less oxygen, producing a wide range of partially oxidized compounds. At Centralia, tests have revealed 45 organic and inorganic chemicals, including toxins like benzene, toluene, and xylene. Similarly, 56 compounds have been identified in the gases from one of China's coal fires.

This takes a major toll of the well being of thousands who must live with these fires. For instance, Centralia today is totally abandoned. The exodus mostly occurred in the early '80s when many persons collapsed due to the carbon monoxide fumes formed as a result of the smouldering coal fires, and one person actually died by falling into the fire due to land subsidence. In Jharia, most villages affected by these fires have seen a dwindling in their populations. Al-jazeera (April 1, 2014) has reported of how people shun matrimonial alliances with those living in the affected villages of Jharia.

Although the Indian government sanctioned Rs 14 crore for the first phase of the shifting of Jharia town way back in 2003, to relocate 50,000 people into Belgharia district, in one of the world's biggest evacuation drives, those who shifted are far from happy. This is because the remoteness of the location, lack of livelihood opportunities, intermittent power supply and other problems have left them dissatisfied (http://ejatlas.org/conflict/jharia-coalfield-fire-india). Thus, the social consequences of relocation of populations are immeasurable, given the circumstances.

Economically, a coal seam fire is a disaster, as it **DESTROYS THOUSANDS OF TONNES OF VALUABLE COAL**. It also causes widespread cracking and subsidence of the land surface.

Preventing Coal Fires: The Way Ahead

Dr Saumitra Mukherjee, professor of Geology, Remote sensing and Space Sciences at the Jawaharlal Nehru University, New Delhi states "the state of coal seam fire in India has two issues, scientific and administrative. In West Bengal, Bihar, Jharkhand and Odisha, the coal is mainly semi bituminous and capable of producing inflammable phenol, cyanide and sulphide compounds. When coal is extracted from thick seams, the geostatic pressure gets disbalanced, initiates land subsidence, and can initiate a fire due to the resulting friction. However, coal mine fires can also be initiated by the cigarette or bidi buds of mine workers as well."

A senior researcher in the Central Institute of Mining and Fuel Research (CIMFR) Dhanbad, on condition of anonymity adds, "Coal heat digressions can cause spontaneous heating leading to a mine fire. Unscientific mining can also act as an aggravator. In India, most mines have a history of mine fires, but chances of them occurring in opencast mining are far higher as compared to underground mines." In his opinion, the hazard of a coal seam fire ought to be prevented by filling up the space left vacant after the extraction of coal with sand bags—termed stowing. This prevents land subsidence and acts to control coal seam fires. Contractors need to complete stowing supervised by mine safety experts. "Negligence in such matters can increase the chances of a coal seam fire," warns Dr Mukherjee.

At the same time, researchers and experts feel a dire need of a monitoring mechanism to ensure mine safety all over the country.

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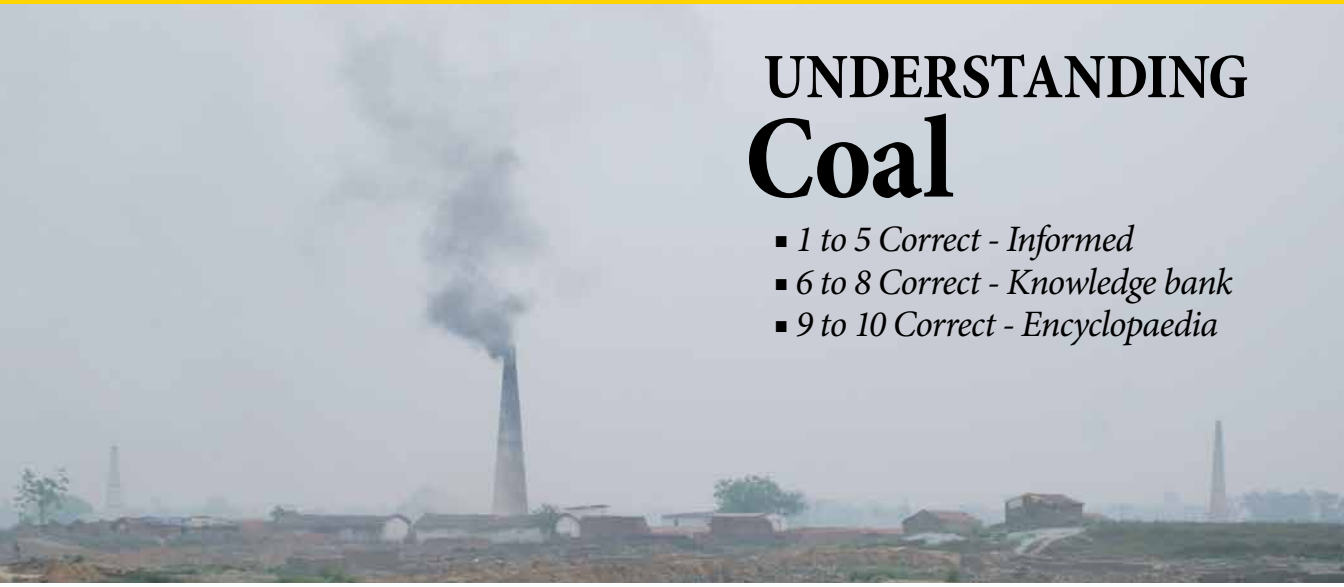

UNDERSTANDING Coal

- *1 to 5 Correct - Informed*
- *6 to 8 Correct - Knowledge bank*
- *9 to 10 Correct - Encyclopaedia*

1. Baghouses

Ans. **a:** A generic name for air pollution equipment which uses a range of filter bags/fabric types to separate particulate (dust, ash, powders, etc.) from the exhausting air stream. It is a required equipment as per the standards set by the Environmental Protection Agency (EPA) to ensure that all industrial exhaust gasses are particulate (dust) free.

2. Boiler

Ans. **b:** A device found in power plants for generating steam for power, processing or heating purposes, or for producing hot water for heating purposes or hot water supply. Heat from an electrical combustion source is transmitted to a fluid contained within the tubes in the boiler shell.

3. Clean Air Act

Ans. **a:** A federal law in the US that defines EPA's responsibilities for protecting and improving its nation's air quality and the stratospheric ozone layer. The Clean Air Act Amendments of 1990 were the last major change in the law, enacted by Congress.

4. Coal additive

Ans. **a:** A type of substance, either liquid, solid or gas, that is manually added to coal for some altering purpose. Some additives are used to even out coal, alter emissions, improve furnace operation and a variety of other purposes.

5. Combustion

Ans. **b:** The process of retrieving energy from the burning of fuels in the most efficient way possible. To maximize combustion efficiency, it is necessary to burn all fuel material with the least amount of waste.

6. Electronic Precipitator

Ans. **a:** An electrostatic precipitator (ESP), or electrostatic air cleaner, is a pollution control device that removes particles from a flowing gas (such as air) using the force of an induced electrostatic charge. ESPs are highly efficient filtration devices.

7. Emission

Ans. **c:** Substances that are released into the air from power generating plants among other sources. Major emissions that are regulated by the federal government are nitrogen oxide, sulphur dioxide and mercury. Carbon dioxide is also a major emission, but is not regulated.

8. Flue Gas

Ans. **a:** A gas that exits into the atmosphere via a flue, which is a pipe or channel for conveying exhaust gases from a fireplace, oven, furnace, boiler or steam generator. Quite often, it refers to the combustion exhaust gas produced at power plants.

9. Flyash

Ans. **b:** Finely divided particles of ash entrained in gases resulting from the combustion of fuel. Approximately six million tonnes of flyash are used each year in the US in major projects such as highway construction.

10. Mercury

Ans. **a:** A metallic element that is toxic to human beings whose emission into the environment through the combustion of coal has come under increasingly tight restrictions. GY

Stranded Assets and Subcritical Coal: The Risk to Companies and Investors, March 2015

Studying coal powered electricity generation, the Stranded Assets Programme at the University of Oxford's Smith School of Enterprise and Environment has systemically looked into the environment related risks driving coal as an asset. A summary of their report, 'Stranded Assets and Subcritical Coal: The risk to Companies and Investors', is presented here.

Stranded assets are assets that have suffered from unanticipated or premature write-downs, devaluations, or conversion to liabilities. Risk factors related to the environment are currently stranding coal, making it a stranded asset.

Coal provides 40 per cent of the world's electricity, with a total installed capacity of 1617 GW worldwide. Of this, 75 per cent is subcritical, 27 per cent supercritical, and 3 per cent ultra- supercritical.

Study says that 99 per cent of India's coal-fired power generation are least efficient globally.

Subcritical is the least efficient and most polluting form of coal-fired generation of electricity. It requires more fuel and water and creates more pollution to generate the same amount of power. The average subcritical coal fired power station emits 75 per cent more carbon pollution than an average advanced ultra- supercritical coal fired power station.

India has a capacity of 10 GW in coal-fired power stations, 99 per cent of which is subcritical. Due to the smaller size and inefficiency of most existing Indian generators, India has recently initiated the setting up of ultra-mega power plants through private capital. However, domestic coal supply remains a critical concern with the potential to strand assets.

India's National Action Plan on climate Change (NAPCC) has set up several missions under its flagship programme with the intention of reducing power generation emissions by 20-25 per cent by 2020 based on 2005 levels. Under the energy efficiency perform achieve trade (PAT) mechanism, power stations are given targets for earning efficiency credits. In case they outperform their targets, they can sell the credits earned. Inaugurated in 2012, with the first binding compliance period ending in March 2015, PAT has heavily impacted the ageing coal-fired power stations.

India is also taking regulatory steps to monitor air quality, in view of 2014 Yale University Environment Performance Index placing India's air quality at 174th out of 178 countries. The Indian government has already announced plans to establish a national air quality index within the next five years, which will involve continuous monitoring of emissions in 66 major cities. A pilot continuous emission monitoring system and credit trading scheme has already been put in place in the states of Maharashtra, Gujarat and Tamil Nadu to check emission of particulate matter (PM).

Most significantly, 33 per cent of Indian coal powered stations are located in extremely water stressed areas. The particulate matter within a 100 km radius in their vicinity is also at levels exceeding the World Health Organization (WHO) limit. Water scarcity can spell two major risks to power generating stations. Lack of enough water can compel power stations to run at half their capacity, hence affecting their profitability. On the other hand, lack of water may cause nationwide blackouts and hence, power crises. Meanwhile, implementation of the 2012 National Water Policy which recognises the need for balancing multiple use of watersheds, can also affect coal power stations.

Thus, the Report concludes, global stock of the most inefficient coal powered electricity generating systems is at stake. GY

A view of the settlers, digesters, anaerobic baffled reactor and planted gravel filters at Kengeri colony, Bangalore

decentralised sanitation

By **Rina Mukherji**

Space constraints prevent Indian cities from laying sewerage lines for new or underserved pockets. DEWATS systems can help here.

Indian cities generate an estimated 38354 million litres per day (MLD) of wastewater. However, only 8.5 per cent of it is treated according to the Central Pollution Control Board. This is because the existing sewage infrastructure in cities is woefully inadequate to treat all the wastewater generated. Untreated water, unfortunately, can find its way into our rivers and streams, or much worse, seep into the soil to contaminate underground aquifers forever.

In most industrial and urban centres, infrastructural and basic services are stretched to the seams. Hence, it is difficult or well-nigh impossible to integrate newer sections into the sewerage and other services. Even within cities, slum pockets remain unserved, posing a major danger to health.

This is where DEWATS, or decentralised wastewater treatment systems can help. The Centre

PHOTO COURTESY: RINA MUKHERJEE

for Advanced Solutions (CASS), of the Centre for DEWATS Dissemination (CDD) Society, set up through the collaborative efforts of the Bremen Overseas Research and Development Association (BORDA), and the Rajiv Gandhi Rural Housing Corporation Limited (RGRHCL), has initiated several such projects all over India.

DEWATS design

In a general DEWATS design, the wastewater—a combination of grey and black water, enters the settler. The settler could be a conventional settler or a biogas settler. The non utilised biogas is let out from a separate pipe. Sludge accumulates at the bottom of the settler.

Making use of the natural gradient of the land, the water then enters an anaerobic baffled reactor and/or anaerobic filter. The naturally occurring microorganisms in the wastewater break down the organic matter. The partially treated wastewater finds its way to the planted gravel filter (PGF), where a selection of plants such as colocasia (arvi), cattail reeds, Canna, Nelumbo, Caltha, Eichhornia, and Sagitarria removes the nutrients and re-oxygenates wastewater naturally. An additional polishing pond exposes the effluent to the atmosphere for final treatment. The treated wastewater can now be directly used for gardening and landscaping purposes. In case the water is to be utilised for flushing purposes, carbon and sand filters have to be used, followed by chlorination.

The Bangalore Metro Rail Corporation Limited (BMRCL) has put up toilets adjacent to MG Road Metro station for rail commuters. Prefabricated DEWATS units are implemented at the two public toilets of the metro stations (one near Anil Kumble Circle and other near MG Road Metro station). Wastewater from the Metro Railway toilets is passed through a pre-fabricated settler and anaerobic baffle reactor. The treated wastewater is then sent into the drains of the city sewerage system. Using Dewats has taken care of the space constraints, while preventing uprooting the urban sewerage system to accommodate the Metro Rail toilets.

This kind of system can prove useful for an unserved urban slum pocket too, as has been done in Kolhapur, Maharashtra, and the beedi workers' resettlement colony in Kengeri satellite town, on the outskirts of Bangalore. Comprising 1600 households resettled in two phases, this colony in Kengeri was too far to be integrated into the Bangalore sewerage system. Hence, connecting the colony would have been a costly affair. DEWATS was put in place. It covered 120 households comprising approximately 700 people. Designed for a capacity of 36 cubic metres of wastewater, it is made up of a biogas settler, anaerobic baffled reactor and a planted gravel filter of cattail reeds and canna.

Cattail reeds, canna and colocasia plants on the planted gravel filter alongside the M G Road Metro station in Bangalore. The settlers, and baffled reactor are installed under the pavement alongside.

The black water from the households is collected and treated in the DEWATS unit. The biogas generated as a byproduct from the (biogas) settler here is used as a fuel in the anganwadi to cook food. This win-win situation has not only improved the hygiene of the colony, but done away with waste discharge.

Hill station towns like Shimla are today struggling to cope with huge populations, and resultant waste generation. The CASS is currently working on similar lines to treat the sewage from unserved pockets and improve hygiene in areas under the Shimla Municipal Corporation (SMC) and four other urban local bodies (ULBs) of Himachal Pradesh, namely Mandi, Dharamshala, Nahan and Hamirpur.

Endnote

As urban agglomerations grow in size, sewerage and water sanitation systems are stretched to their limits. Decentralised sanitation systems use the minimum amount of land, to the maximum advantage. They not only take care of sanitation, but recycle wastewater and contribute to saving precious groundwater resources. GY

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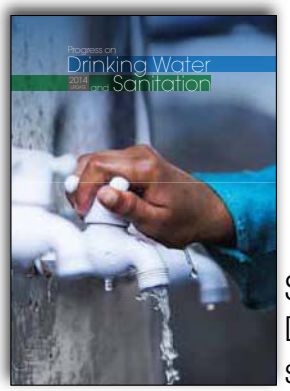

South Asia Report: Drinking water and sanitation, 2014

According to a United Nations International Children's Education Fund (UNICEF) Report compiled with the World Health Organisation (WHO), 'Progress on Drinking Water and Sanitation- 2014 Update', over two billion people have gained access to improved sources of drinking water, and 116 countries have met the millennium development goals (MDG) target for water.

Almost two billion people have also gained access to sanitation and 77 countries have met the MDG target in this respect. Nearly four billion people, which are half of the world's population, have access to piped water connection in their homes. Yet, a lot remains to be done, since as the Report points out, 700 million people still lack ready access to improved drinking water. Nearly half of this population is in sub-Saharan Africa.

Where South Asia is concerned, great strides have been made in providing piped and improved drinking water to both its rural and urban populations. The urban population in this region have 100 per cent access to clean water. Of this, 54 per cent of the urban population have piped water on their premises. Of the rest, 42 per cent of the urban population has access to improved water. Only 4 per cent of urban population have to make do with unimproved water. Surface water is never used by urban populations. As for the rural population 15 per cent have access to piped, 74 per cent have access to improved and 10 per cent of the rural population use unimproved water. Surface water is used by one per cent of the rural population.

But, most stark of all is that two billion people, that is, a third of the global population, lack improved sanitation facilities; of these, one billion people continue with open defecation. Between 1990 to 2012, open defecation decreased globally from 24 per cent to 14 percent, with South Asia showing the biggest decline, from 65 per cent to 38 per cent, as Jan Eliasson, Deputy Secretary-General, United Nations, has pointed out.

Since 1990, sanitation coverage increased by 21 percentage points in developing regions; today, 57 per cent of the people in the developing world have access to an improved sanitation facility. Despite some progress on the sanitation front, the number of people lacking an improved sanitation facility dropped by just 0.7 per cent from 2.7 per cent in 1990 to 2.0 billion in 2012. There are 46 countries where less than half the population have an improved sanitation facility, notes the UN.

Among the world's regions, southern Asia and sub-Saharan Africa continue to have the lowest levels of sanitation coverage. Even so, Southern Asia has seen usage of improved sanitation facilities to have increased by 19 percentage points to reach 42 per cent since 1990. Yet, 40 per cent of those without an improved sanitation facility are in southern Asia.

> India is one of the 10 countries that are home to 82 per cent of the global population practising open defecation.

Within the region, rural and urban disparities are rife where open defecation is concerned. In south Asia, 53 per cent of the rural population still practise open defecation. Only 31 per cent enjoy improved sanitation, while 7 per cent rely on shared facility, and 9 per cent have to rely on an unimproved facility.

In the urban areas of South Asia, 9 per cent resort to open defecation. Here, 64 per cent enjoy improved defecation, while 18 per cent use a shared facility. Also 9 per cent of the urban population have to rely on an unimproved facility.

India is one of the 69 countries who are not on track in meeting the MDG sanitation target. It is also one of 10 countries that are home to 82 per cent of the global population practising open defecation. To this day, 597 million Indians continue to practise open defecation.

At this rate, the UN warns, the world is unlikely to reach the MDG target of 75 per cent sanitation coverage by 2015. GY

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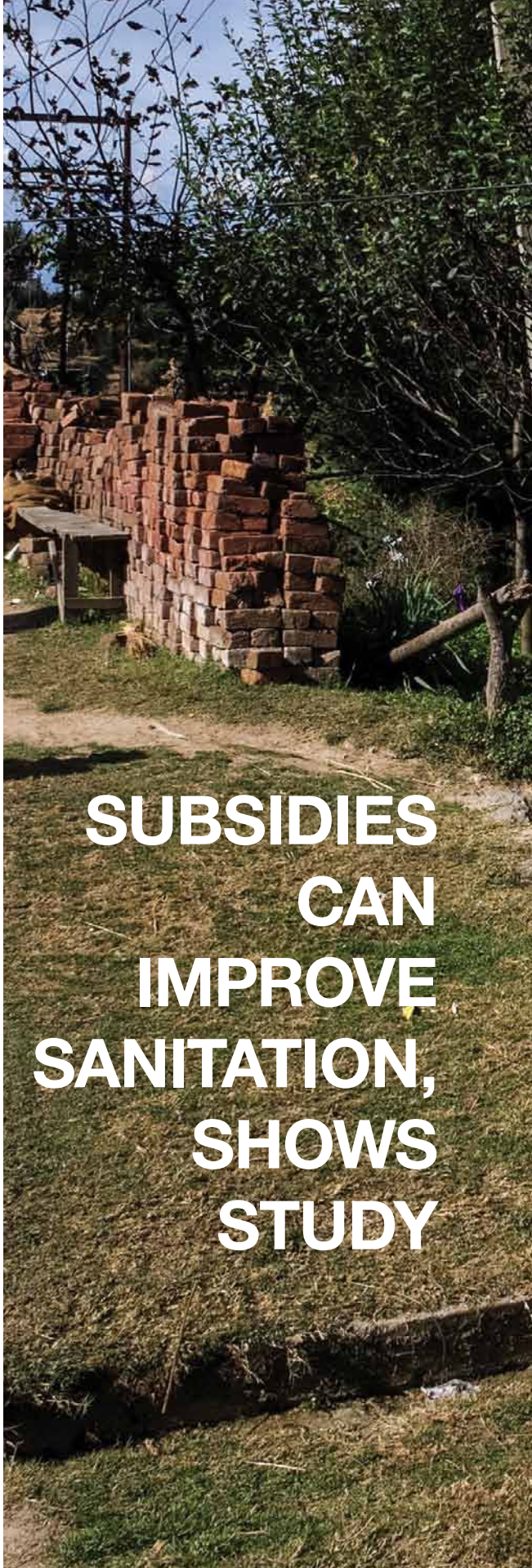
SUBSIDIES CAN IMPROVE SANITATION, SHOWS STUDY

A new study in *Science* found that subsidies may be the key policy.

By **Staff Reporter**



With poor sanitation estimated to cause 280,000 deaths per year worldwide, improving sanitation is a key policy goal in many developing countries. Yet governments and major development institutions disagree over how to address the problem. A new study released in *Science* in April, 2015 found that in Bangladesh, a community-motivation model that has been used in over 60 countries to increase use of hygienic latrines had no effect. Yet latrine coverage expanded substantially when that model was combined with subsidies for hygienic latrines targeted to the poor.

The study, led by Raymond Guiteras of University of Maryland and James Levinsohn and Mushfiq Mobarak of Yale University, and implemented by Innovations for Poverty Action, tested three different approaches that are commonly used in the development sector for increasing the use of hygienic latrines. Reducing open defecation, which is still practiced by 15 per cent of the world's population, is a key policy goal for this sector. The study was undertaken in northwest Bangladesh, in an area where 50 per cent of the population had access to a hygienic latrine before the study began.

Researchers randomly assigned 380 neigh-

Latrine coverage may expand substantially when subsidies for hygienic latrines are targeted to the poor.

Latrine investment decisions are inter-linked across neighbours, and there are positive effects on others of subsidising even a few households.

bourhood communities, to one of four groups. Villages either received a community motivation programme, subsidy vouchers with the community motivation programme, information and technical support, or none of the above. By comparing outcomes in latrine coverage, investment in hygienic latrines, and open defecation between the groups over time, researchers were able to compare the effect of the different approaches.

The subsidy vouchers, which were only provided to a random subset of households in the second group through a public lottery, could be redeemed for a 75 per cent discount on available models of latrines, priced (after subsidy) from 5 to 12 USD. The households were responsible for their own transportation and installation costs, and the richest 25 per cent of households were not eligible for vouchers. The community motivation programme, called the Latrine Promotion Programme (LPP), was modelled after 'Community-led total sanitation', which focuses on behavioural change and community mobilisation in eliminating open defecation.

Researchers found that the community motivation model alone did not significantly increase adoption of hygienic latrines or reduce open defection relative to the comparison group, nor did providing information and technical support to community members. However, the subsidy had substantial effects when coupled with the community motivation programme, increasing hygienic latrine coverage by 22 percentage points among subsidised households and 8.5 percentage points among their unsubsidised neighbours.

This suggests that latrine investment decisions are inter-linked across neighbours, and that there are positive effects on others of subsidising even a few households. People were more likely to invest if more of their neighbours received vouchers, pointing to a virtuous cycle where adoption of improved latrines spurs further adoption. Adding subsidies to the community motivation model also reduced open defecation rates by 22 per cent among adults in villages that received subsidies (including households that did not receive subsidies), relative to the comparison group.

These results counter the concern among many development practitioners that subsidies undermine intrinsic motivation. Rather, this research shows price is a primary barrier, which is consistent with a growing body of research on adoption of health products.

These results are especially useful as Swachh Bharat Abhiyaan is one of the top priorities of Indian government today. GY

—Inputs from Sharanya Chandran, Policy Manager, J-PAL South Asia at IFMR.

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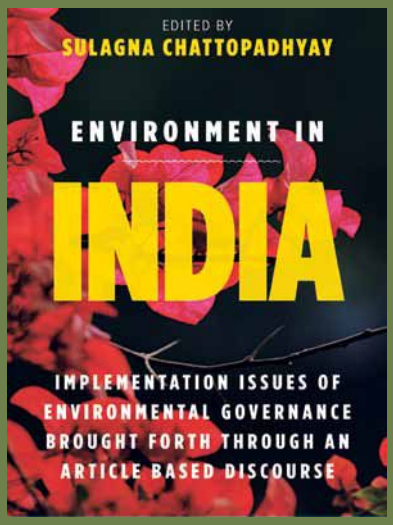

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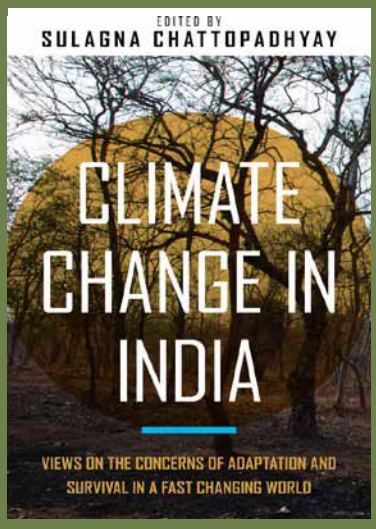

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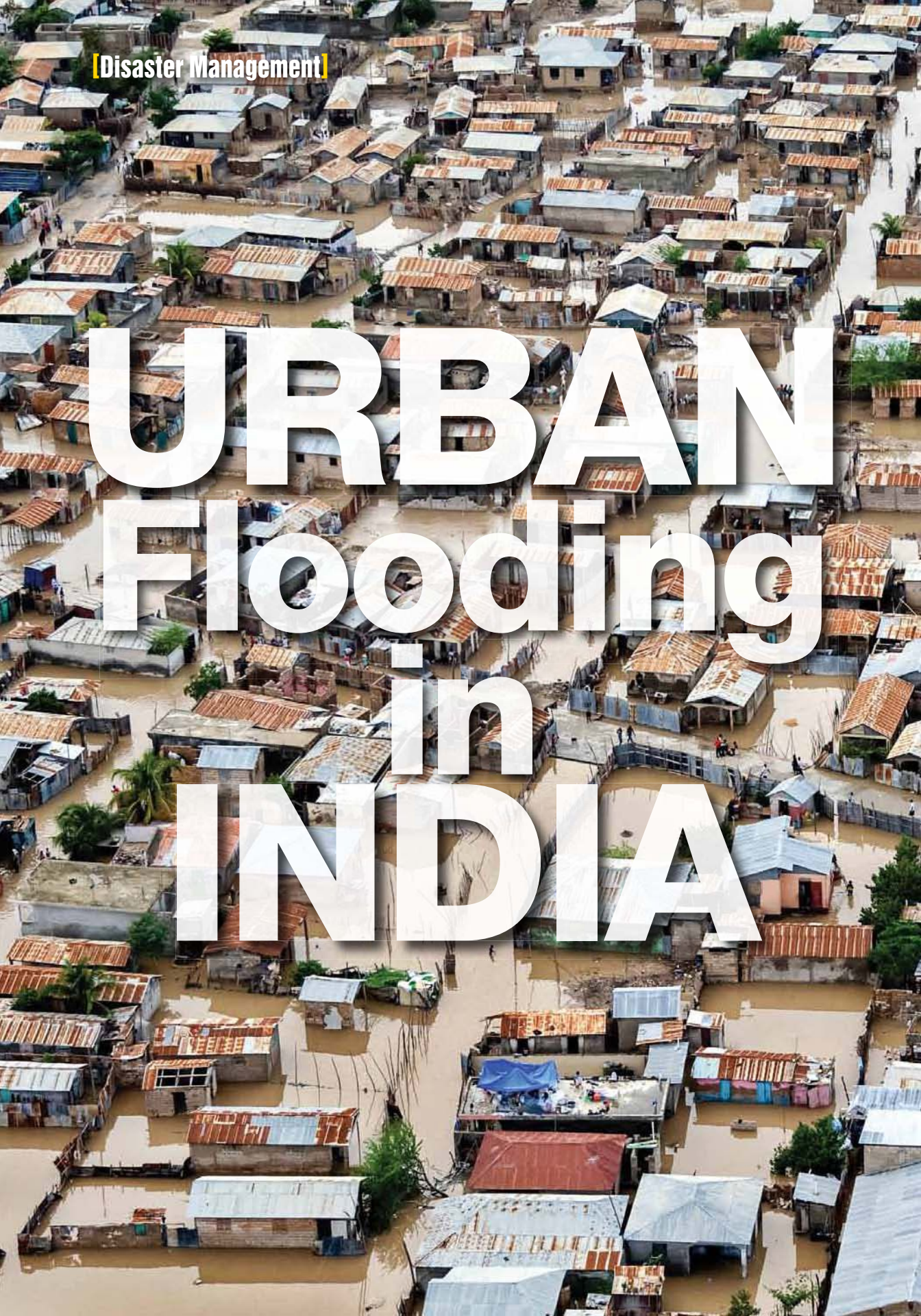
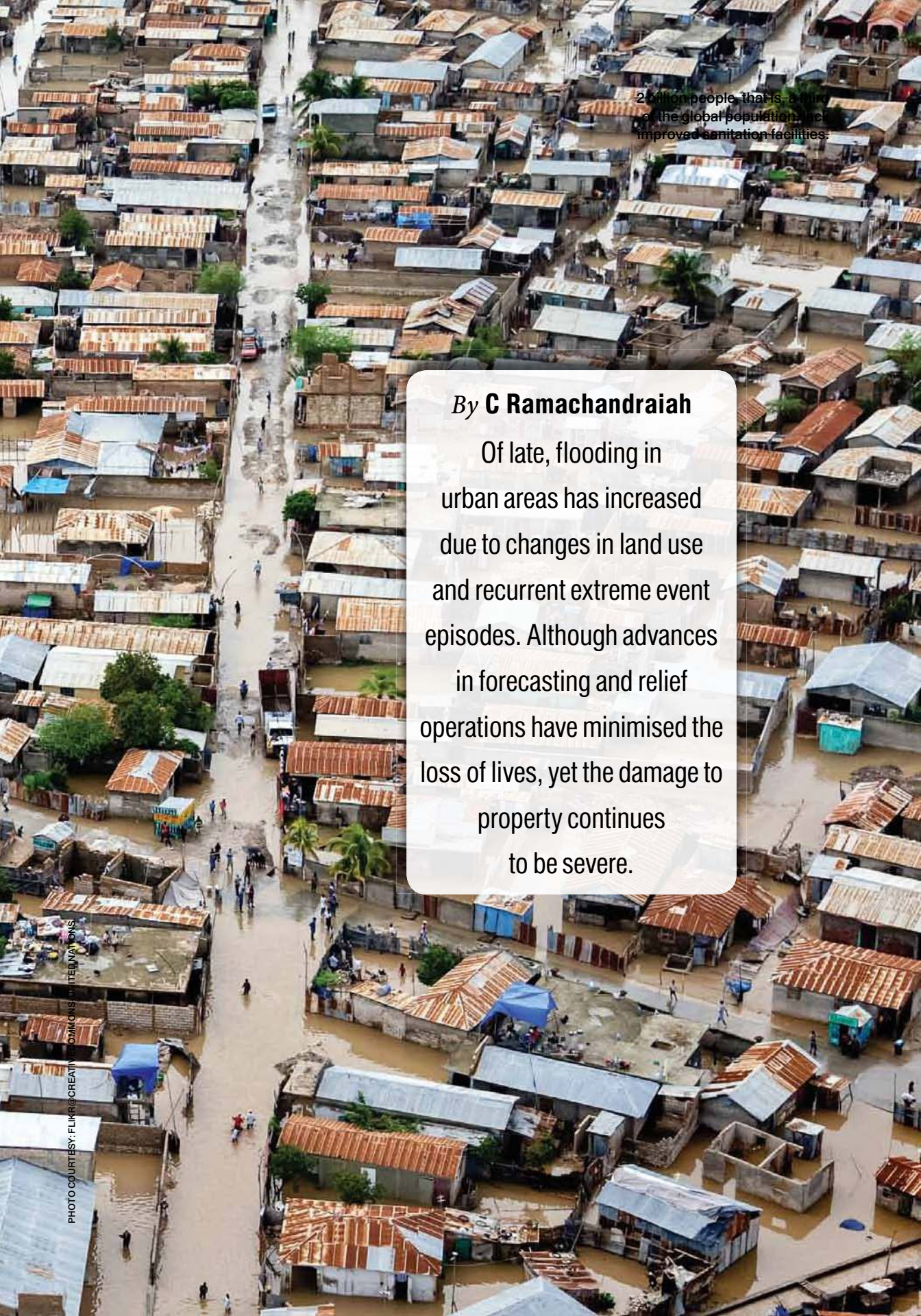


URBAN Flooding in INDIA



2 billion people, that is, a third of the global population, lack improved sanitation facilities.

By **C Ramachandraiah**

Of late, flooding in urban areas has increased due to changes in land use and recurrent extreme event episodes. Although advances in forecasting and relief operations have minimised the loss of lives, yet the damage to property continues to be severe.

PHOTO COURTESY: FLIKR@CREATIVECOMMONS/UNITEDNATIONS

Urban flooding is a rising phenomenon in recent times. Whether coastal or inland, flooding in an urban centre can cause grave damage owing to the high population density involved.

Moreover, the capacity of Indian cities to withstand heavy rains has also weakened owing to land use changes and interference with natural watersheds. Thus, notwithstanding the improved accuracy of forecasts and communications, as also the administrative efficiency in tackling floods, cities have ended up becoming more vulnerable to floods. The unprecedented floods that left Mumbai, Hyderabad, Surat and Bangalore reeling in recent times only prove this true. Rainfall variations and extreme event episodes have only succeeded in making things worse.

The authorities have prioritised cities for economic growth and employment generation, but without any focus on protection of water bodies and water channels. Reclaiming large tracts of land for building has left many cities bereft of wetlands and water bodies that can absorb urban outflows during the monsoon. Consequently, recurring urban floods are an annual occurrence today.

In an urban setting, flooding results in large scale disruption of power, transport, water supply, sanitation and other basic utilities. This in turn can pose additional problems, resulting in a crisis that is unmanageable owing to its sheer volume and intensity. With the capacity of the administration stretched to its limits, the affected people end up the worst sufferers, as pointed out by R Chigurupati 2008 paper 'Urban growth, loss of water bodies and flooding in Indian cities: The case of Hyderabad', in J Feyen, *et. al.* edited, Water and Urban Development Paradigms: Towards an Integration of Engineering, Design and Management Approaches, published by CRC Press/Balkema and Taylor & Francis Group, London.

Such extreme events are estimated to increasingly occur, especially owing to heavier precipitation resulting in an increase in frequency and proportion of heavy rainfall episodes. According to D Dutta and S Herath's undated article, 'Trend of floods in Asia and flood risk management with integrated river basin approach', flood frequency is increasing in all Asian countries owing to climate and land use changes. Whenever a flood occurs, the poor and low-income groups are four times as likely to suffer or die. Given that, floods are by far the most frequent and devastating of natural disasters in Asia, it has sizably increased the vulnerability of the urban poor of late.

In recent times, the most well documented case of flooding in a mega city has been that experienced by Mumbai in July 2005 when 94.4 cm of rain received in a span of 14 hours causing a deluge of hitherto unimaginable proportions. One of the major causes behind the flooding was the blocking of the 14 km long Mithi river, and reducing it into one third its size, to create acres of office space in the posh Bandra- Kurla complex. The city paid its price when several went missing and died in the deluge that flooded the city, and rendered it immobile for days without power and water.

The floods in the first week of August, 2006 displaced lakhs of people in Surat, Vadodara, Broach and several other cities and towns in Gujarat, when more than 0.25 million had to be evacuated to safer places. With 70 per cent of Surat under 8-10 feet of water, people were issued an advisory to move to places that were at least 20 feet higher than the ground level.

Bangalore, the 'Silicon Valley of India', has been experiencing frequent floods for the last several years. The reason for this is not far to seek. The city had about 262 lakes until 30 years ago; the number had come down to 81, as revealed by the Central Pollution Control Board in its 1999-2000 Annual Report. At present, media reports claim the presence of 60 lakes, the health of most being questionable.

Renowned for its undulating topography and its scenic lakes, Hyderabad has lost many of its water bodies in the last few decades due to encroachments. Environmentalists feel that a repeat of the August 2000 floods that paralysed Hyderabad for days could be ten times worse today. This is because dozens of housing colonies have sprung up in and around the city's lakes, blocking inflows into water bodies.

Kurnool town, on the right bank of the river Tungabhadra, experienced one of its worst floods in October, 2009. The rainfall was estimated to be the highest in about 100 years. Several areas were submerged in more than 30 feet water, and it took more than three days for the water to recede completely. There were heavy inflows into the three rivers, which merge into each other in and outside Kurnool town. A number of tanks were breached and the Sunkesula Barrage across Tungabhadra, upstream from Kurnool, was washed away. These rivers received inflows far in excess of their carrying

The Kurnool flood of October 2009 took the city by surprise as the area has often been alluded to as drought affected.

capacities resulting in inundation of the town. During the same time there was a rare phenomenon of synchronisation of peak inflows from the three rivers into the Srisailam reservoir. An unprecedented inflow of 26 lakh cusecs, described as the 'maximum probable flood' in the Krishna basin flowed into the Srisailam reservoir. This saw the top of the Srisailam dam tilt towards the downstream side by 8.8 mm. About 11.56 sq km or 30 per cent of Kurnool town was submerged, with 3.36 sq km of that area experiencing upto 13 m (42.5 ft) of submergence.

Incidentally, the worst inundation took place in a low lying area sandwiched between the Tungabhadra and Hundri rivers. Luckily, since the flooding occurred during the day, the loss of lives was negligible. Massive relief operation involving personnel and machinery from several urban local bodies in Andhra Pradesh reined in the disaster, and limited the damage. However, it is important to note that this heavy flooding occurred in Kurnool after the district had been declared drought-affected due to scanty rainfall, in September 2009. Even otherwise, Kurnool lies in the zone of scanty rainfall receiving 500–750 mm per annum. At the time of the flood, all dams in Karnataka, that is, the upper riparian State were full and the Srisailam reservoir, downstream of Kurnool, was also nearly full. Yet, the Nagarjunasagar reservoir, further downstream of Srisailam, was nearly half empty.

Experts attribute the backwater effect of the Srisailam reservoir (which extends upto Kurnool town) for aggravating the intensity of the floods. However, the Kurnool floods threw up several issues in water management pertaining to river basins that cover different states. For instance, it has been argued that matters could have been possibly controlled by releasing a good amount of water from Srisailam into Nagarjunasagar.

On October 12, 2014, Visakhapatnam was hit by a very severe cyclonic storm, Hudhud. The cyclone caused extensive damage to the city and the neighbouring districts of Vizianagaram and Srikakulam . At the time of impact, the wind force was estimated to be 200 km/hour, and the height of the waves reached up to 3 m. This was the first time in more than a hundred years that a city had been hit by a cyclone in full force.

Endnote

The importance of cities as vehicles of economic growth and development are well realized by the authorities. Yet, changing land use patterns in utter disregard of the natural channels and water-bodies that have controlled urban outflows for centuries is costing everyone dear. Unless we revamp our theories of urban planning and give due importance to watersheds, the erratic weather patterns and rainfall characteristic of climate change will throw up frequent natural disasters in our urban centres that will be difficult to manage, given population densities, which multiply every problem several times over.

The author is a Professor of Geography, Centre for Economic and Social Studies, Hyderabad.
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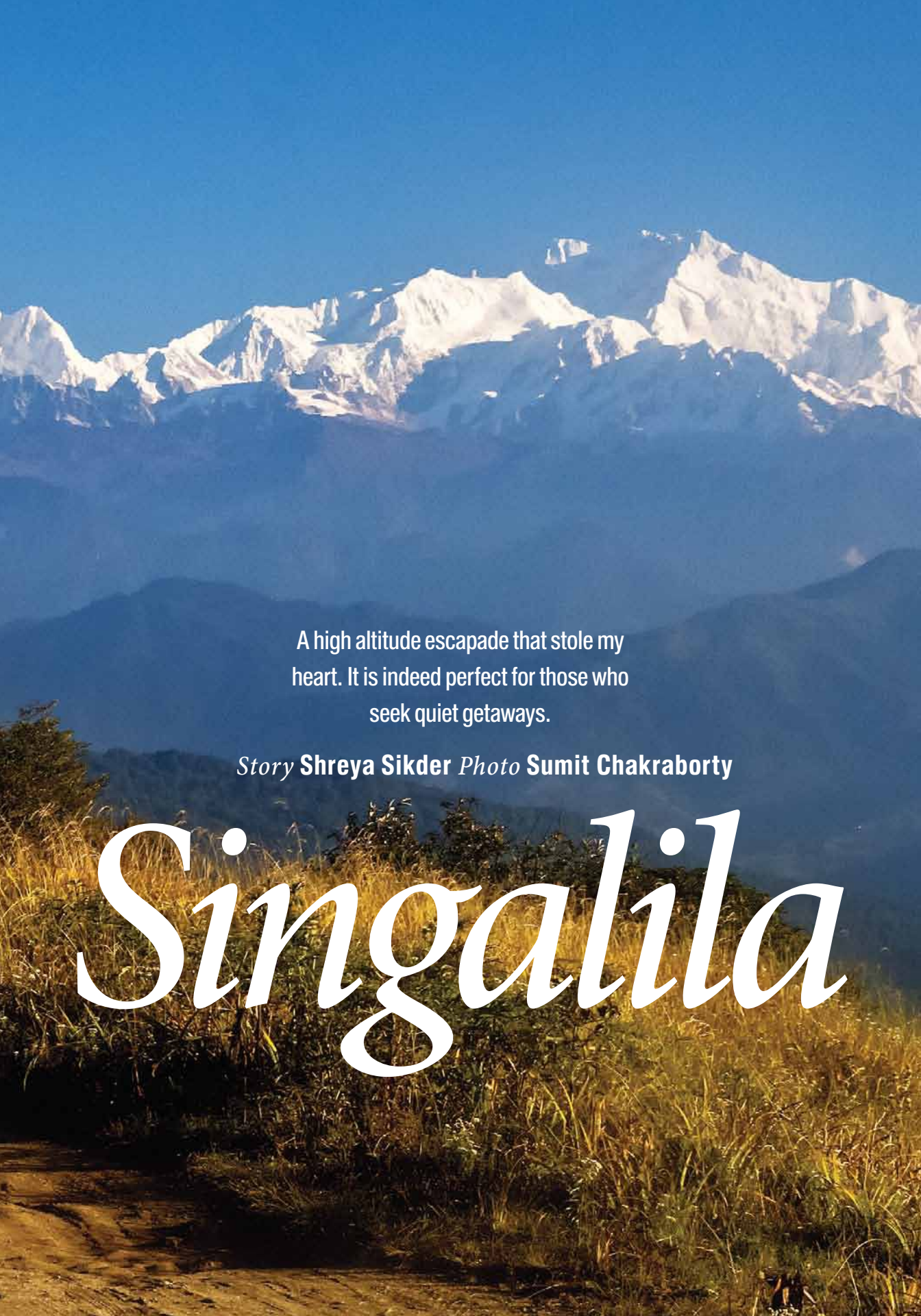
PHOTO COURTESY: AUTHOR

In the afternoon we trudged along to a cliff near Tonglu to get a better view of the Kanchenjunga and Singalila range.



A high altitude escapade that stole my heart. It is indeed perfect for those who seek quiet getaways.

Story **Shreya Sikder** *Photo* **Sumit Chakraborty**

Singalila

The Tonglu lake *en route* to Sandakphu. The forked Kabru, Kanchenjunga and Simvo peaks may be seen in the distance.

It was all excitement, and some trepidation as I boarded the night train to New Jalpaiguri (NJP) on April 12, on my first ever trip to the Singalila National Park. As the train chugged into New Jalpaiguri station at 10 am next morning; out came our rucksacks, cameras and, tripods. We emerged into the station and sought the cars that would take us to Dhotrey, our first halt before we moved to Tonglu. The snow-covered oak, pine and birch, with glimpses of a few khalij pheasants amid the icy drizzle were a visual treat as we drove up the mountains.

It was about 4 pm when we reached Dhotrey, a village with some 70 odd huts located 8500 ft above sea level. The grumpy sky turned from gray to pitch dark as we tucked ourselves into warm blankets for a restful night in the wooden cottage.

Way to Tonglu

Notwithstanding the comfort of our warm beds, the excitement of viewing the Kanchenjunga and Singalila range at close quarters made me dash out just as the eastern sky was beginning to brighten. The icy cold breeze caressed my face as I stood awe-struck admiring the magnificent Kanchenjunga bathed in gold. I hurriedly dressed in trekking attire and set out to conquer Tonglu (10074 ft). Strapping on our belongings we began our ascent to Tonglu, the gateway to Singalila National Park in Darjeeling district.

The Singalila National Park is a high altitude park with virgin Rhododendron forests—declared a wildlife sanctuary in 1986, it became a national park in 1992. Spanning 78.9 sq km at an altitude of 7900-12000 ft, its thick Rhododendron forests running north to south separates Himalayan West Bengal from ranges west of it.

Shortly after Manebhanjan (2134 m), the forest stretches through Tonglu, Tumling, Garibas and all the way up to the two highest peaks of West Bengal, Sandakphu (11909 ft) and Phalut (11811 ft) which are located on the ridge within the Park. Lying as it does in the Indo-Malaya ecozone, the Park presents the Eastern Himalayan subalpine temperate coniferous biome (ranging from 3000 m to 4500 m), the Himalayan subtropical coniferous pine forests (ranging from 1800 m to 3000 m) along with the Eastern Himalayan temperate broad leaf and mixed forests.

Being a first time trekker, I found it hard to keep pace with the experienced ones in our group. It was

strenuous ascending the rough, stony trail. Past noon the gateway of the 'Tonglu Medicinal Plant Conservation Area' greeted us. We were housed at Raju *bhaiya's* small but cozy cottage. After a hearty meal, we rested awhile watching translucent clouds floating about. Later in the afternoon we decided to climb the nearby cliff and get a better view of the resplendent setting sun and found ourselves chilled to the bone. Back at the trekkers' hut, we warmed our numbed hands over a charcoal fire before dozing off after a delicious dinner of rice and chicken. The last memories of the day was a brilliantly star lit sky, framed by the little window in my room.

The next morning, the forest was engulfed in a thick mist. We loaded our equipment and headed towards Tumling (9600 ft), which was about 1.2 km from Tonglu. Tumling, placed at the gates of the Park, is a small hamlet that borders Sikkim in the north and Nepal on the west. The route through the Park provides breathtaking views of the Eastern Himalayas from Tonglu (3050 m), Tumling (2900 m), Meghma (2600 m), Garibas (2612 m), Joubari (2750 m), Kalopokhri (3186 m) and Rimbik (2286 m). On a clear day, one can see the snow clad Kanchenjunga stretching over 300 km from Nepal through Sikkim and Bhutan, and right up to Arunachal Pradesh.

Sipping hot cups of tea, we photographed many beautiful birds, and some vignettes of rural life in the mountains. Breakfast was at Shikhar Lodge, where we took time off to recharge our cameras and mobile phones. Neela Gurung who plays an active role in keeping the trekking routes along the Park garbage free, owns the Lodge. En route to Meghma, we spotted the white collared blackbird, stonechat, blue-fronted redstart, citrine wagtail, white-browed fulvetta and Himalayan griffon. By the time we reached the Buddhist monastery at Meghma, it was late afternoon. The road went down to the military barracks, our last stop on the route. Beyond this, we would ascend to Tonglu. But, thick grey clouds closed in, and in no time, heavy rains followed. We rushed back to our cottage and remained confined for the rest of the day.

On the last day at Singalila National Park, there was just time enough to soak in beauty of the pristine villages around, before we headed back to Tonglu. Kalipokhri is a small hamlet at an altitude of 3000 m *en route* to Sandakphu, and is deemed holy for Buddhists. Rimbik is a secluded village perched atop a hill overlooking river Rammam,

Brown throated Fulvetta sighted on the way to Tonglu

which flows from Sikkim into West Bengal. Facing the majestic Himalayas, surrounded by green hills, tea gardens and conifers, and overrun with orchids, Rimbik is a rich tapestry of flora and fauna.

As one treks within the Park, between 2000 m and 3600 m, thickets of bamboo, oak, pine, hemlock, juniper, kawla, bhujpatra, silver fir, ferns and various flowering plants present itself. There are two flowering seasons, in spring (March-April) and the post-monsoon months (October-November). Rhododendron (*Rhododendron ferrugineum*) and Magnolia (*Magnolia grandiflora*) bloom in the springtime, while the lower forests are in full bloom in the post-monsoon period. The lower forests comprise primula (*Primula vulgaris*), geranium (*Pelargonium hortorum*), saxifraga (*Saxifragacespitosa*), bistort (*Persicariabistorta*), senecio (Senecio vulgaris), cotoneaster (*Cotoneaster salicifolius*) and over 600 varieties of orchids .

Soon, it was time to leave. A group photo proceeded the quick descend to Dhotrey. By noon we were enjoying platefuls of steamed momos. Home bound cars arrived and we bid the mountains a final adieu.

How to Reach

The nearest airport is Bagdogra (90 km from Darjeeling and 13 km from Siliguri).The nearest railway station is Ghoom, 31 km from Tonglu. National Highway 31A between Sevoke and Gangtok also passes through Darjeeling, and is one and a half hour journey by car from Manebhanjan, which is the entry point into Singalila National Park. There is another, though longer route via Mirik in Sikkim.

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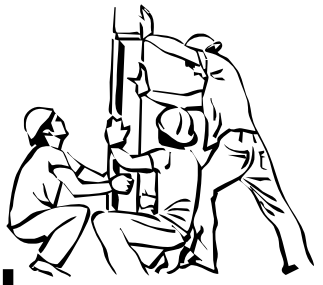

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