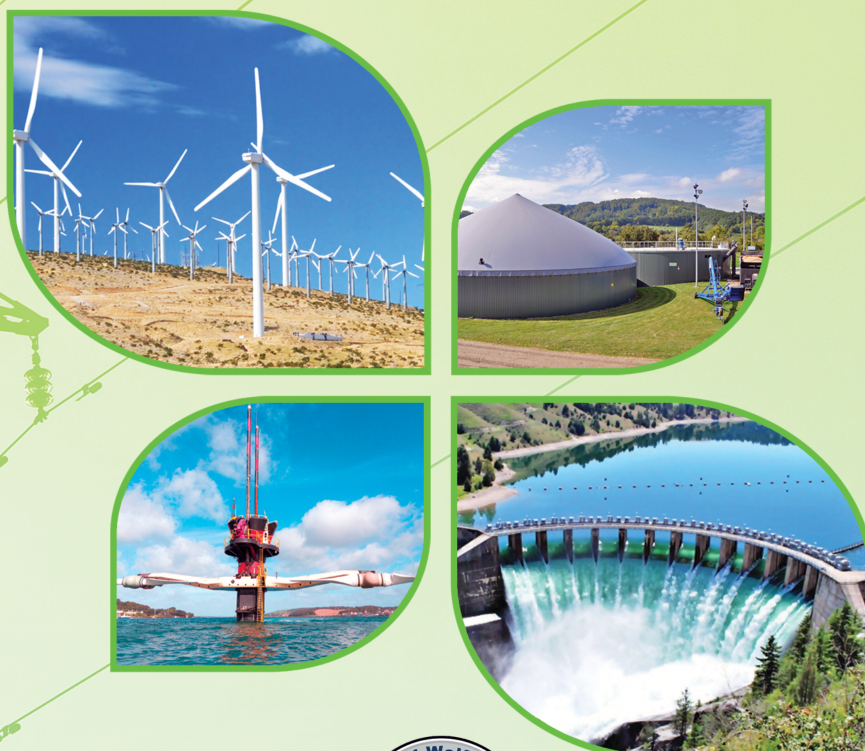
VOLUME -VI

POWER GENXT

Published on the day (05.11.2017) of 6th National Seminar

"Survival of the greenest- A transition of India's Power Sector"



Engineers' Welfare Forum
WBPDCL
ISO 9001 : 2015 CERTIFIED

ENGINEERS' WELFARE FORUM

THE WEST BENGAL POWER DEVELOPMENT CORPORATION LIMITED

Website : www.wbpdclewf.org.in, E-mail : wbpdclewf@gmail.com, Fax : 03228-231 578

(Recognised by WBPDCL Vide Letter No. : PDCL/CORP./HR/305/1495, Dated 3.3.2012)

NEED
National Energy Excellence Drive
2017

6th National Seminar of EWF at Swabhumi,Kolkata,Dated: 5.11.2017

Madhumanti Maitra
(EMCEE)

Er. Soumen Das
(General Secretary, EWF)

Sri Sobhandeb Chattopadhyay
(MIC, Power & NES, Govt. of WB)

Dr. Souvik Bhattacharya
(Vice Chancellor, BITS, Pilani)

Dr. Sivaji Chakravorty
(Director, NIT, Calicut)

Sri Sutirtha Bhattacharya, IAS
(Principal Advisor, Govt. of WB)

Er. Debapriya Mitra
(President, EWF)

Dr. Rintu Banerjee
(Professor, IIT, Kharagpur)

Dr. Jayanta Bhattacharya
(Professor, IIT, Kharagpur)

Dr. Subhashis Biswas
(Director, BITM, Shantiniketan)

Dr. Sumantra Bhattacharya
(Professor, IIT-ISM, Dhanbad)

Er. Rajib Das
(DGM, CESC)

Dr. Shuvendu Bose
(ED, Earnst & Young, New Delhi)

Dr. Niladri Chakraborty
(Professor, JU)

Er. Sudip Nag
(GM, NTPC-Noida)

Er. Prasanta Sinha
(Treasurer, EWF)

POWER GENXT

VOLUME -VI

Published on the day (05.11.2017) of

6th National Seminar

"Survival of the greenest- A transition of India's Power Sector"

ENGINEERS' WELFARE FORUM, WBPDCL

Website : www.wbpdclewf.org.in, E-mail : wbpdclewf@gmail.com, Fax : 03251-260160

(Recognised by WBPDCL Vide Letter No. : PDCL/CORP./HR/305/1495, Dated 3.3.2012)

NEED

National Energy Excellence Drive

2017

CONTENTS

Sobhandeb Chattopadhyay
Minister-in-Charge
Power & NES Department
Government of West Bengal

सत्यमेव जयते

শোভনদেব চট্টোপাধ্যায়
মন্ত্রী
বিদ্যুৎ ও অচিরাচরিত শক্তি
উৎস বিভাগ
পশ্চিমবঙ্গ সরকার

No.850–MIC/Power/17 November 01, 2017

MESSAGE

I am very delighted to learn that **Engineers' Welfare Forum of WBPDCL** is going to organize a National Seminar on "**Survival of the Greenest-A Transition of India's Power Sector"** on 05th November, 2017 at Swabhumi (Rangmanch), Kolkata-54. One of the objects of holding this seminar is to inform and motivate all concerned.

I also appreciate the initiatives taken by the Forum to publish a Technical journal **POWER GENXT, Vol.-VI** to commemorate this special occasion.

I covey my very best wishes to all the members of the Forum and wish the programme great success.

(Sobhandeb Chattopadhyay)

To
The General Secretary,
Engineers' Welfare Forum, WBPDCL,
Bidyut Unnayan Bhavan,
Bidhannagar,
Kolkata-700 098.

Bidyut Unnayan Bhaban, 6th Floor, 3/C, LA- Block, Sector-III, Bidhannagar. Kolkata-700 098
Ph. +91-33-2335-0768, Fax : +91-33-2335-5151

ENGINEERS' WELFARE FORUM
Regn. No. : S / 1L / 74829
THE WEST BENGAL POWER DEVELOPMENT CORPORATION LIMITED

MANOJIT KUMAR BASAK
B. Sc. (Ph. Hons.), B. Tech. (App. Ph.), M. Tech. (App. Ph.), Gold Medalist (CU), Life Member (IEI), C. Eng. (IEI)
Chief Advisor & Founder Ex. President

Residence:
Flat No. C1 "**ASHIRBAD**"
7/1, Bhattacharjee Para Lane, Kolkata-700036
Mob: 9432987079/7980004291
e-Mail: manojit1952@gmail.com

Date: 01-11-2017

Message

*I am very much glad and proud that "**Engineers' Welfare Forum, WBPDCL",** one and only one registered (Regd. No. S/1L/74829) under the West Bengal Society Registration Act. 1961 and recognized (by **WBPDCL** Vide their letter No: PDCL/CORP/HR/305/1495 dated : 03-03-2012) association formed by the engineers of West Bengal's Premier Power Generating Company, "**The West Bengal Power Development Corporation Limited"** has organized a National Seminar on **Survival of the Greenest - A Transition of India's Power Sector"** on **5th November 2017** at **Swabhumi Rang Manch, Kolkata -700 054**. Since our fossil fuels i.e. coal, oil, and natural gas are gradually going to end from our earth, our scientist and technologist are going towards **Green Energy** which comes from natural sources such as sunlight, wind, rain, tides, plants, algae and geothermal heat for the Indian Power Sector. Green Energy is also having a much smaller impact on the environment than fossil fuels. This transition is the burning issue for the mankind. As an Indian Citizen, fruitful thinking about this matter and its implementation is the prime task of the Engineers and Technologists attached to the different power sector of India as well as in abroad. This seminar will help to create a platform for knowledge shearing among the well experienced engineers of different power sectors.*

*On the same auspicious day **Engineers' Welfare Forum, WBPDCL** will publish their technical journal "**POWER GENXT, Vol-6"** which will also be the knowledge shearing platform for the Engineers.*

I extend my best wishes to all the Members i.e. my brothers and sisters, of the forum, the participants of the seminar, the different organizations who helps the forum to organize the seminar, the co-worker and wish the seminar a grand success.

(MANOJIT KUMAR BASAK)

Second Generation Ethanol Production from Agricultural Residues

Prof Rintu Banerjee
Agricultural and Food Engineering Department, IIT Kharagpur

Introduction

The global energy demand has been continuously increased from past 10 years that caused a scarcity in the supply of crude oil. Globally, research has been shifted form conventional sources to alternative clean and sustainable energy sources. Agricultural residues represent one of the abundant and viable biomass feedstock. The exploitation of lignocellulosic waste such as residues obtained from agricultural practices for biofuel production is one of the viable options which will help to reduce the burden on fossil fuels utilization and greenhouse gas emission. Current situation demands the production of lignocellulosic biofuels to control the energy crisis [1].

Lignocellulosic biomass is mainly composed of by three key polymers namely, cellulose, hemi cellulose, and lignin. Cellulose and hemicelluloses contributes to the total carbohydrate content of the biomass and packed tightly with the lignin that form a barrier around cellulose and hemicelluloses polymers. Deconstruction/removal of lignin to utilize the cellulose and hemi cellulose requires selective pre treatment techniques that only target the lignin polymer without affecting the structural properties of cellulose and hemicelluloses [2].

It has been estimated that from lignicoellulosic biomass, approximately 442 billion liters of ethanol can be produced per year and 491 billion liters of ethanol can be generated from crop residues per year which is about 16 times more than actual global bio ethanol production [3]. Lignocelluloses biomasses are abundant, low cost and renewable in nature. It includes a large variety of feed stocks such as crop residues, sawdust, grasses, wood chips, forest residues etc. From the last two decades, extensive research has been done on second generation (2G) ethanol production [4, 5]. Hence, 2G ethanol generation could be the viable platform for effective utilization of the waste produced from agriculture sector. Rice straw, sugarcane baggase, corn straw and wheat straw are the major agricultural wastes. In terms of surplus biomass availability and total carbohydrate content these waste feed stocks can be valorize to fermentable sugar and in turn to ethanol in an eco-friendly manner which not only minimize the green house gas emissions but also makes the process cost-effective [3].

Materials and Methods

Raw material

The four major agro-wastes (rice straw, wheat straw, corn straw and sugarcane bagasse) were selected due to their availability throughout the year.

Biochemical characterisation

The moisture content of agricultural residues was estimated by standard protocols of Association of Analytical Communities (AOAC) [6]. Total lignin and residual lignin was estimated by titrimetric method [7].Reducing sugar estimation was done by dinitrosalicylic acid [8]. Cellulose content of the biomass was measured by following the "semi-micro determination of cellulose" method [9] whereas anthrone method was used for hemicellulose estimation [10]. Ethanol content was estimated by potassium dichromate method [11].

Biomass pretreatment

Lignin degradation was carried out for all the substrates through different modes chemical and physic-chemical of biomass pretreatment. Pretreatment/delignification of agricultural residues was carried out in a conical flask, containing required amount of substrate and chemicals under a defined reaction conditions. Samples were taken out after a fixed incubation period followed by solid liquid separation. Then the separated solid biomass was washed with distilled water and oven dried overnight at 60 °C. The oven dried biomass was subsequently used for final lignin or residual lignin estimation by titrimetric method.

Enzymatic saccharification

For saccharification process, the pretreated substrates were treated with appropriate amount of cellulolytic enzyme for certain incubation time. Thereafter, the broth was separated from the substrate and centrifuged. The clear filtrate was used to estimate the amount of reducing sugar.

Methodology for fermentation

Simultaneous saccharification and fermentation (SSF) of the pretreated substrates were carried out in an Erlenmeyer flask with required amount of biomass, cellulolytic enzyme and yeast under defined reaction conditions.

Results and discussion

Biochemical compositional analysis

The compositional analysis of any lignocellulosic biomass reveals it's potential to be serving as a robust feedstock for biofuels generation. In fact, it is the main criteria from which one can decide or select the feedstock for biofuel generation. The biochemical compositional analysis of the agricultural residues revealed the high cellulose and hemicelluloses. An efficient pretreatment process was indeed necessary to degrade the high amount of lignin of these feedstocks to utilize further the cellulose and hemicellulose. The compositional analyses of the substrates were given Table 1.

Table 1. Biochemical composition of the raw substrates

Biomass	Cellulose (%, w/w)	Hemicellulose (%, w/w)	Lignin (%, w/w)
Rice straw	32.00	19.00	24.00
Wheat straw	35.00	20.00	15.00
Corn straw	42.60	21.30	8.20
Bagasse	35.20	24.50	22.20

Biomass pretreatment for lignin degradation

The major challenge in the biofuel production process is the biomass deconstruction to degrade recalcitrant lignin molecule. The main constituents of the lignocellulosic biomass are cellulose, hemicelluloses and lignin. The cellulose moieties are usually covered with lignin which acts as a barrier and prevent the access to the cellulosic portion of the biomass. Delignification solubilises or degrades the lignin of the biomass and makes the remaining solid residue more accessible to saccharifying enzymes. The pretreated or delignified biomass further subjected to enzymatic saccharification for reducing sugar production. The pretreatment yield in terms of lignin degradation for the above mentioned substrates were given in Table 2.

Table 2. Pretreatment yield of the agro-residues

Biomass	Pretreatment yield (%)
Rice straw	94.49 ± 2.1
Wheat straw	88.00 ± 1.5
Corn straw	87.60 ± 1.45
Bagasse	93.5 ± 2.7

Enzymatic hydrolysis of pretreated substrate

Saccharification or hydrolysis is the most critical step in bioethanol production process where hollocelluloses are converted into simple sugar monomers. In general, enzymatic hydrolysis for fermentable sugar production was preferred over chemical methods due to mild process conditions and less energy requirement [12]. The optimum conditions for the saccahrifying enzymes have been reported to be 40-50 ^{o}C and pH 4-5 [13, 14]. The enzymatic process is more effective for the conversion of lignocellulosic biomass into saccharides, e.g., cellobiose and glucose, since it can be carried out under mild conditions to achieve a high yield of the final products [15]. Attempts for value addition to agricultural residues for the productions of biofuels and chemicals have centered on screening enzymes with improved hydrolytic capabilities [16]. Enzymatic hydrolysis is carried out by cellulase-xylanase cocktail which is highly substrate specific. Sugar yield of the above mentioned agricultural residues were given in Table 3.

Table 3. Reducing sugar yield of lignocellulosic biomass

Biomass	Yield of sugars
Rice straw	20.00 g/L
Wheat straw	14.50 g/L
Corn straw	80.30 g/L
Bagasse	93.50 g/L

Fermentation

The delignified biomass was further used for ethanol production through SSF. *S. cerevisae* is the commonly used fermenting microorganism for ethanol generation. To make the ethanol production process commercially viable, the fermenting microorganisms should have broad range of substrate utilization, high yield and productivity, ability to sustain high temperature and ethanol concentrations. Ethanol yield from agro-residues were represented in Table 4.

Table 4. Ethanol yield from different lignocellulosic biomass

Biomass	Fermenting microbe	Ethanol yield
Rice straw	*Saccahromyces cerevisae*	4 g/L
Wheat straw	*S. cerevisae*	0.41 g/g
Corn straw	*S. cerevisae* and *Pichia stipitis* NRRL Y-7124	0.50 g/g
Bagasse	*S. cerevisae*	0.29 g/g

Conclusion

Lignocellulosic biomass has been considered as the prime resources for 2G ethanol refinery. Though the theoretical yields of ethanol from starch and sugar are higher compared to the lignocelluloses, these conventional edible biomass sources are unable to meet the worldwide demand of bioethanol. In this perspective, agricultural residues hold good potential for biofuel and biochemicals generation because of abundant, low cost and renewable in nature. Moreover, agricultural wastes do not have any requirements of land, water and energy. They do not have either food-fodder vs. fuel issues. The bottlenecks associated with the fuel conversion technology can be resolve through novel science and cutting edge technologies which will help to optimize and develop the fuel production process from agricultural residues in the near future.

References

[1] J. Tollefson, *Nature.,* 2008, 451, 880–883.

[2] P. R. Waghmare, A. A. Kadam, G. D. Saratale and S. P. Govindwar, *Bioresour. Technol.,* 2014, 168, 136–141.

[3] S. Kim, B.E. Dale, *Biomass Bioenerg*., 2004, 26, 361-375.

[4] L. Cadoche, G.D. Lopez, *Biology of Wastes.,* 1989, 30, 153-157.

[5] P. Binod, R. Sindhu, R.R. Singhania, S.Vikram, L. Devi, S. Nagalakshmi, N. Kurien, R.K. Sukumaran, A. Pandey, *Bioresour. Technol.,* 2010,101,4767-4674.

[6] AOAC, Official methods of analysis, Association of Official Analytical Chemists, Maryland, USA, 17th edn, 2000.

[7] M. A. Hussain, M. E. Huq, and S. M. Rahman, *Pak J. Biol. Sci.*, 2002, 5, 5217522.

[8] G. L. Miller, *Anal. Chem.*, 1959, 31, 426–428.

[9] D. M. Updegraff, *Anal Biochem.*, 1969, 32, 4207424.

[10] J. A. Marlett, and S. C. Lee, *J. Food Sci.*, 2006, 45, 1688?1693.

[11] H.B. Seo, H.J. Kim, O.K. Lee, J.H. Ha, H.Y. Lee, K.H. Jung, *J. Ind. Microbiol. Biotechnol.,* 2009, 36, 285–292.

[12] S. Ferreira, A.P. Durate, M.H.L. Ribeiro, J.A. Queiroz, F.C. Domingues, *Biochem. Eng. J.,* 2009, 45, 192-200.

[13] M.A. Neves, T. Kimura, N. Shimizu, M. Nakajima, *Global Science Books*., 2007, 1-13

[14] Y.S. Park, S.W. Kang, J.S. Lee, S.I. Hong, S.W. Kim, *Appl. Microbiol. Biotechnol.,* 2002, 58, 761-766.

[15] H. Kobayashi, and A. Fukuoka*, Green Chem.,* 2013, 15, 1740-1763.

[16] M. E. Himmel, S.Y. Ding, D.K. Johnson, W.S. Adney, M.R. Nimlos, J.W. Brady, *Science.,* 2007, 315, 804–807

❄❄❄

Coal Quality Changes in Open Air Stockpiling

Barun Kumar Nandi and **Sumantra Bhattacharya**
Department of Fuel and Mineral Engineering
Indian Institute of Technology (Indian School of Mines) Dhanbad
<bhattac1957@yahoo.co.in>

INTRODUCTION

Open air stockpiling of coal is a common practice in the coal fired power plants of India irrespective of the locations of the utilities, close to the coal sources (pit head), within 500km of the sources, near the ports or in the interiors far away from the coal mines and ports. Most of the coal stockpiles in power plants are open type formed by the rail mounted, slewing type stackers. The most common life of the coal stockpiles range from 7 days to 45 days requirement of the utilities. In terms of tonnage, this would be about 50,000 Tonnes to 800,000 Tonnes.

Storage of coal in the stockpile is necessary to take care of any disruptions in the transport system or in the coal mines due to which coal cannot be received at the utilities on such days or over a period. The general practice is to provide a 7-15 days stockpile in case of a pit head utility depending on the reliability of the mines and the transportation system. In case the utility is far away from the coal mines, coal stock of 30 days requirement will be provided. In case coal is received by ships, stockpile of 45 days capacity will be provided, as the reliability of shipping will be less due to variations in the weather conditions especially during the monsoon period [1]. There are however instances independent of plant locations where coal is stockpiled for a much longer period of 8-9 months. When regular supply continues the stockpiled coal usually remains stationery in the coal yard irrespective of the changes in weather.

An investigation was therefore undertaken to analyse the effect of year long weather changes on various characteristics of stockpiled coal which are important in the process of milling and combustion.

METHODOLOGY

For the purpose of investigation an open air approximately 500t stockpile of relatively low rank coal with no cover whatsoever was made at a power plant site located in Singrauli coalfield. The utility has a history of stockpiling in its coal yard for long time periods. The stockpile, formed on a concrete floor, was of a conical shape with a height of about 5m and base diameter of approximately 3.5m. After removing the surface layers representative samples of coal were collected from different locations of the stockpile on the first day of every month on day and night basis. Morning samples were collected just before or around the sun rise. Evening samples were collected just after the sun set. After preparation of the collected samples at the station laboratory approximately 500 gm of -12.5 mm coal sample was delivered to IIT (ISM) Dhanbad. Total 23 coal samples were received. Following characteristics were and are being determined in the laboratory for all the samples on as received basis.

a) Hardgrove Grindability Index (HGI)
b) Gross Calorific Value (GCV)
c) Proximate Analysis and Fuel Ratio (FC/VM)
d) Ultimate analysis and C/H ratio

As on date HGI, GCV determination and ultimate analysis have been completed and those results are discussed here after.

RESULTS AND DISCUSSION

Hardgrove Grindability Index

Hardgrove Grindability Index (HGI) is the most common parameter used to characterize the hardness of coal. It is extensively used to determine the amenability of a coal to crushing and milling. Detailed test procedure for HGI is given in IS 4433 (Indian Standard – Method for determination of Hardgrove Grindability Index of coal). Larger the HGI values, softer are the coal. Figure 1 shows the month by month variation of HGI for the stockpiled coal. Overall HGI results indicate that coal is moderately soft. According to the US and Indian (CMPDI/ ISM) nomenclature coal is classified as soft, the range being HGI: >70 (US nomenclature) and 70-100 (Indian nomenclature).

The grindability of coal as represented by HGI is a composite property embracing other specific properties of coal, such as hardness, strength, tenacity, and fracture. Weathering is the tendency of coal to break apart when they dry out. It is well known that nearly all coals in contact with the atmosphere sooner or later show signs of weathering. Low rank coals show a pronounced tendency to disintegrate or slack when on exposure to weather, particularly when alternately wetted or dried or subjected to hot sunshine. Slackening causes the formation of an excessive amount of fines at the expense of the coarser sizes [2]. Disintegration or slackening of coal leads to reduced presence of cracks, fractures and fissures in coal. That usually makes coal difficult to grind reflected by lower values of HGI.

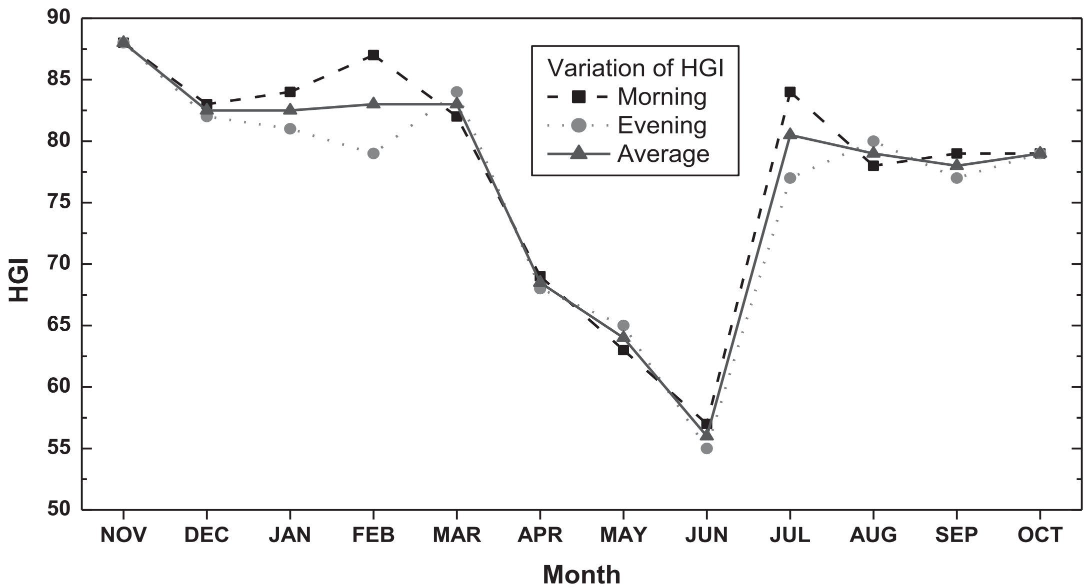


Figure 1: Month by month variation of HGI of the open air stockpile coal

It is observed from Figure 1 that HGI is relatively low during summer months of April to June compared to the remaining months of the year. During summer months the stockpiled coal gets dried due to climatic conditions prevailing at Singurali coalfield such as sunshine, heat waves and very low relative humidity. In remaining months of the year surface moisture gets added to the coal because of rainfall in monsoon and dew drops in autumn and winter along with occasional rains. Except the monsoon months of July to October morning samples show somewhat larger HGI values possibly because of the absence of day time heat and sunshine leading to moisture reduction in the stockpiled coal. Some, though not so significant, HGI variation is observed in morning and evening samples. Since the months involved are January plus February and July the variation could be because of dew drops typical for winter and monsoon rain, respectively. The variation could however also be because of sampling and analytical errors.

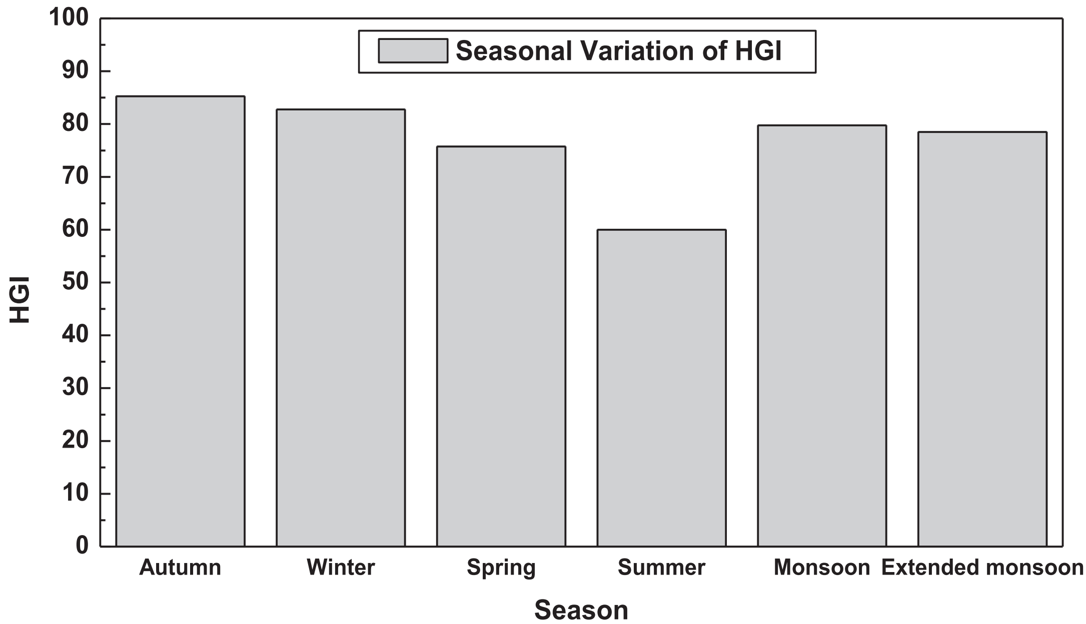


Figure 2: Seasonal variation of HGI of the open air stockpile coal

Yearly climatic conditions in India are divided into six seasons on bi-monthly basis. Therefore, the data presented in Figure 1 have been grouped on seasonal basis and are presented in Figure 2. It is observed from the figure that except summer months through the other seasons HGI of the open air stockpiled coal remains broadly consistent at the level of 80±5. The variation of ±5 could be attributed to the variability of coal characteristics, errors in sample collection and subsequent preparation, sample sealing and in sample analysis. HGI however drops to the level of about 60 in summer, a reduction by approximately 25%, making it a hard coal by both US and Indian nomenclature. This reduction has already been explained on the basis of weathering induced slackening or disintegration of the stockpiled coal in dry summer period. HGI reduction is bound to increase the auxiliary power consumption in crushing and milling. A good stockpiling strategy **from the view point of HGI** could therefore be to avoid stockpiling in summer months. Stockpiling could begin at the end of summer and completely evacuating the stockpile before the next summer begins.

Ultimate Analysis Results

The ultimate analysis from a dried sample is classically defined as the determination of carbon, hydrogen, sulfur, nitrogen, and ash and the estimation of oxygen by difference [2].

Carbon content

Fig. 3 shows month by month variation of carbon content of the stockpiled coal. It is observed that carbon content of the coal decreases from 52.5% to 34.2% during storage. There is practically no decrease in the initial period of storage with largest drop in the dry winter months followed by steady decline in the subsequent months. In the months of March – April nominal difference can be observed in morning versus evening samples. Seasonal variation of carbon content is shown in Fig. 4. Carbon content decreases on season to season basis, the drop being maximum for autumn to winter and minimum for monsoon to extended monsoon. It is however a steady decline. The trend observed is in agreement with a previous study carried out for a high rank North Karanpura coal over a period of eight months [3]. Continuous decline in carbon content of the stockpiled coal should be a major concern for utilities as carbon is the primary source of energy in coal and mostly contribute to the GCV.

Hydrogen content

Fig. 5 showing month by month variation of hydrogen content in coal indicate that the same decrease from 3.71 % to 2.51 % during storage. Other than the months of December and February, morning and evening samples show practically the same hydrogen content. On month to month basis there is however steady decline, sharpest decrease being through the months of November to January. Quite significant seasonal variation of hydrogen content is shown in Fig. 6, major decline taking place between autumn and winter. Continuous decline in hydrogen content of the stockpiled coal should also be a major concern for utilities as in addition to carbon hydrogen is a major source of energy in coal contributing to GCV.

Carbon and hydrogen content decline appears to be due to the heat release on wetting because of the exposure of the coal stockpile to alternate rain + humid weather and sunshine + dry climate.

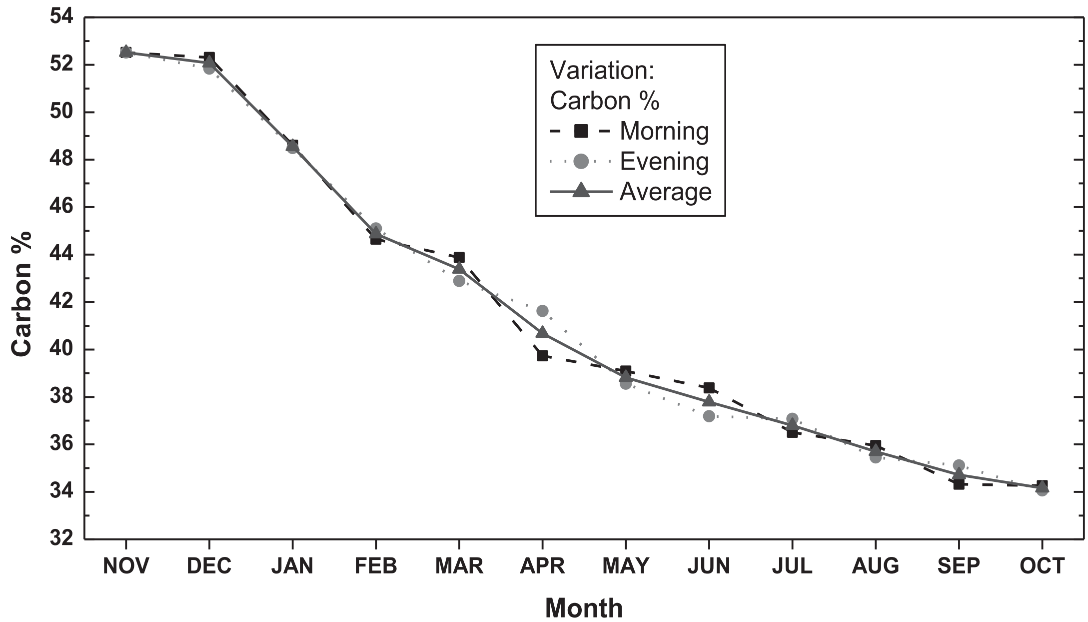


Figure 3: Month by month variation of carbon content of the open air stockpile coal

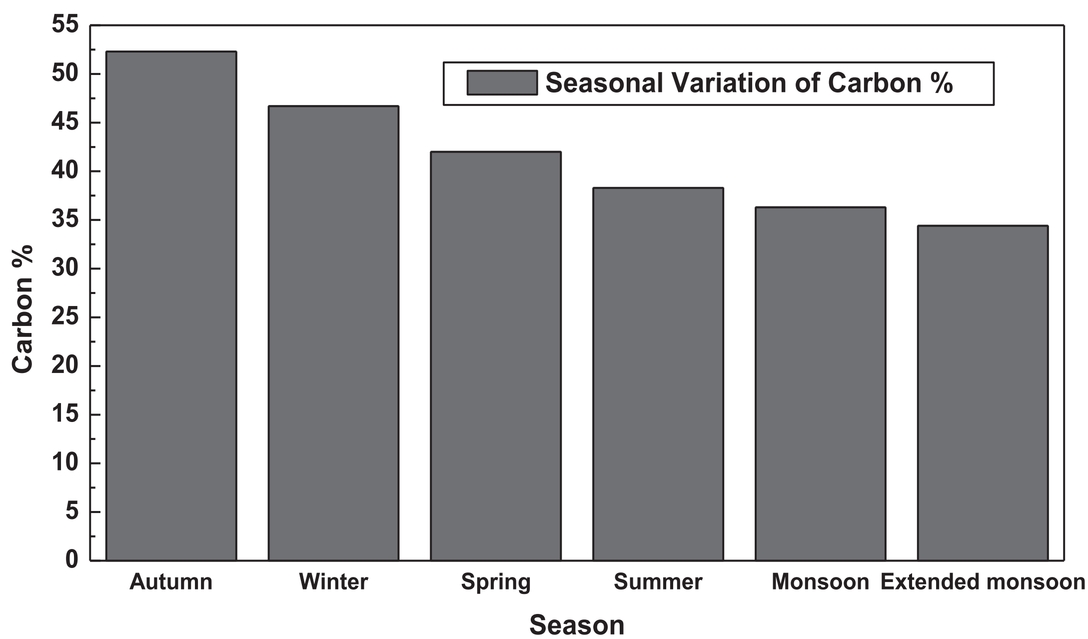


Figure 4: Seasonal variation of carbon content of the open air stockpile coal

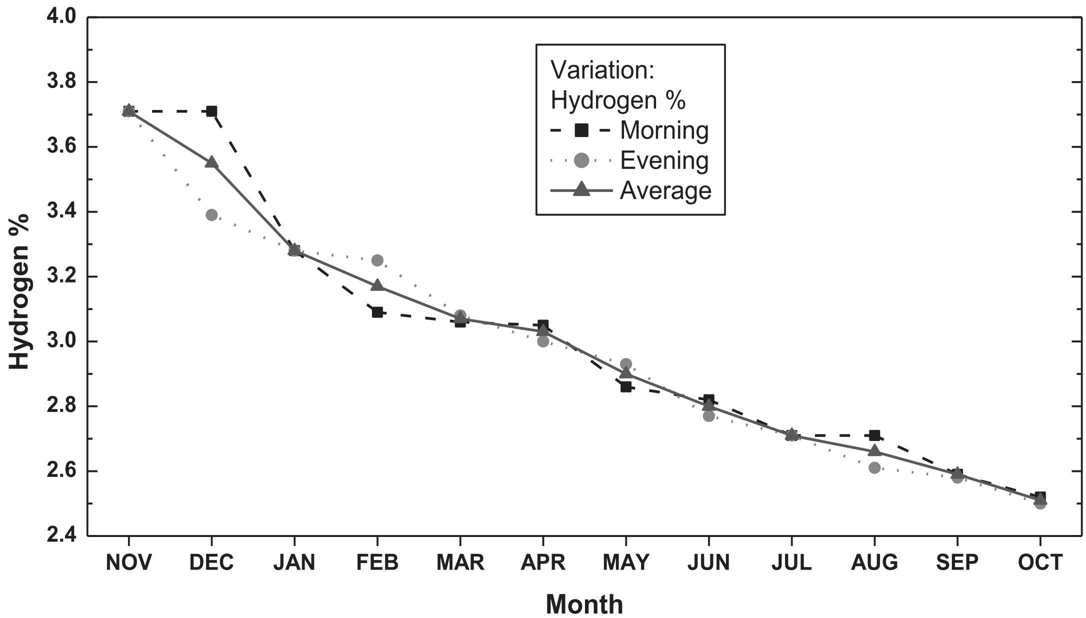


Figure 5: Month by month variation of hydrogen content of the open air stockpile coal

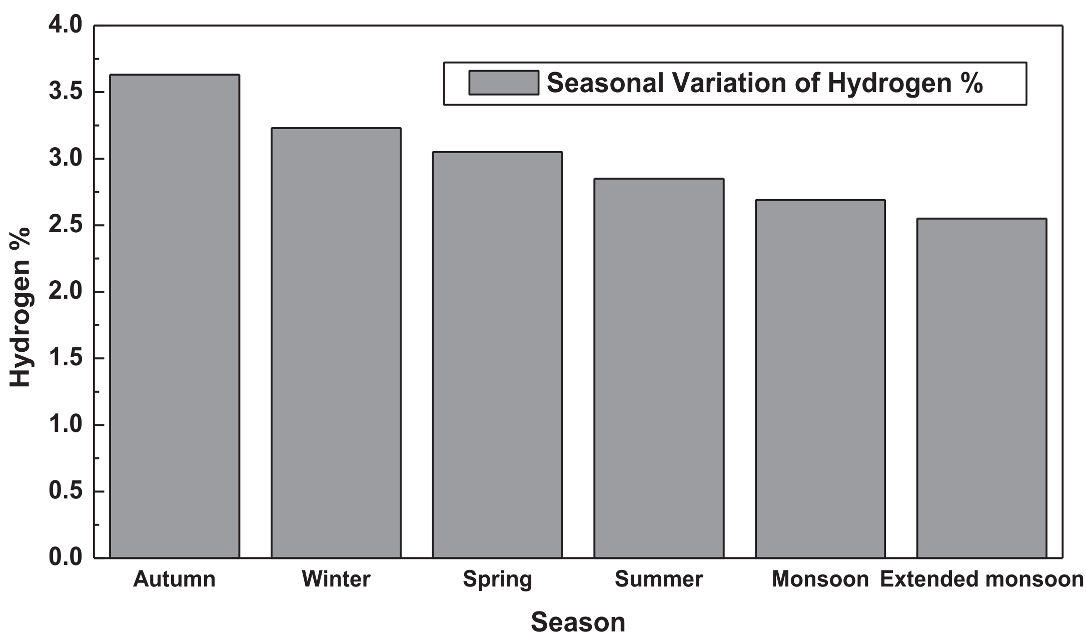


Figure 6: Seasonal variation of hydrogen content of the open air stockpile coal

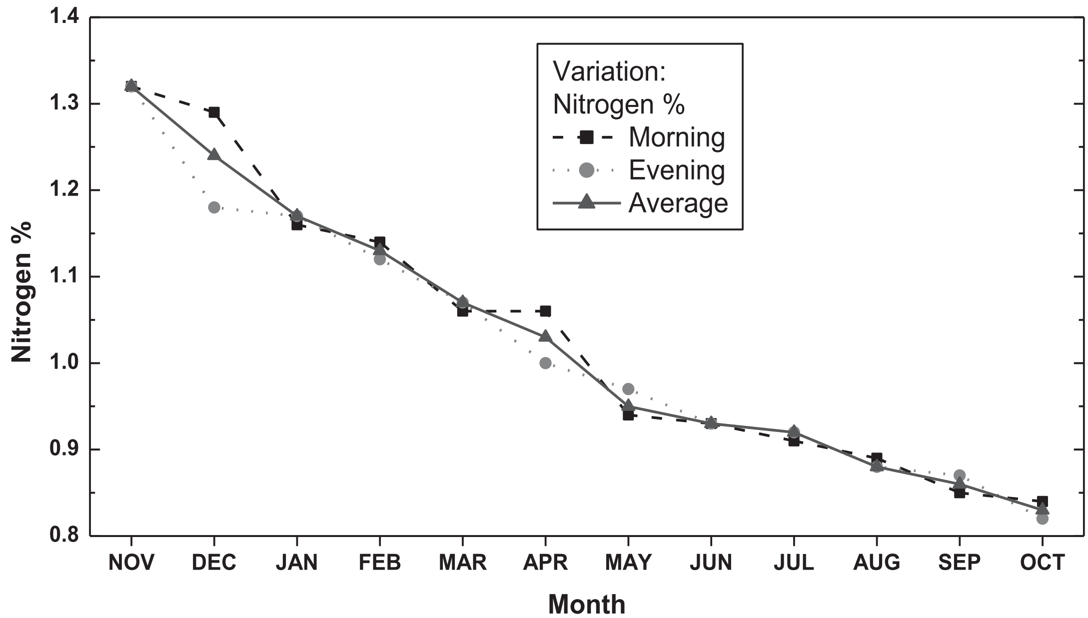


Figure 7: Month by month variation of nitrogen content of the open air stockpile coal

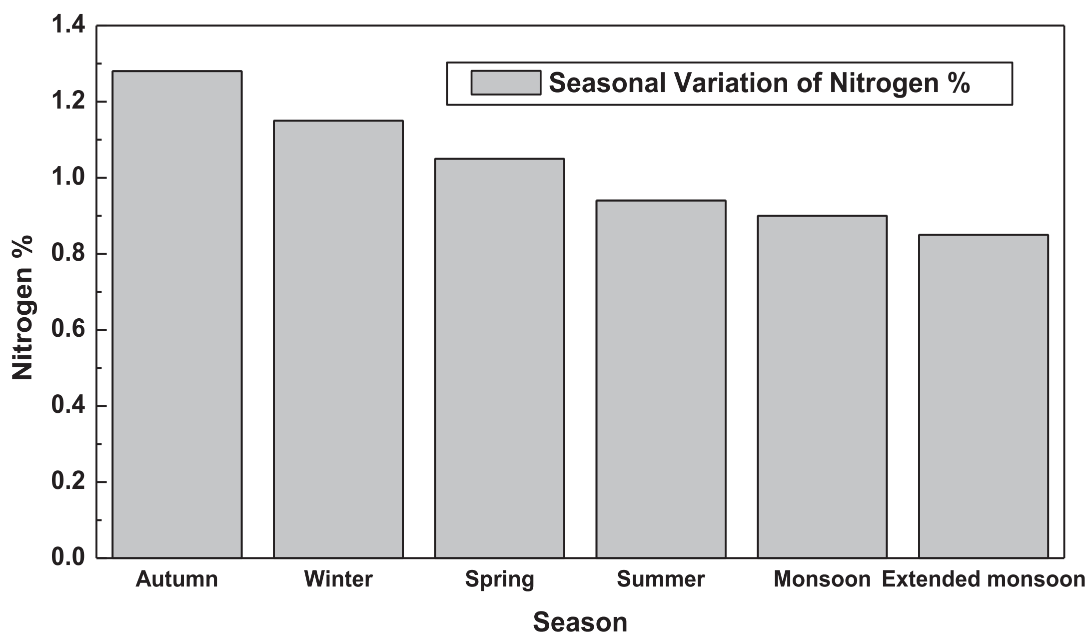


Figure 8: Seasonal variation of nitrogen content of the open air stockpile coal

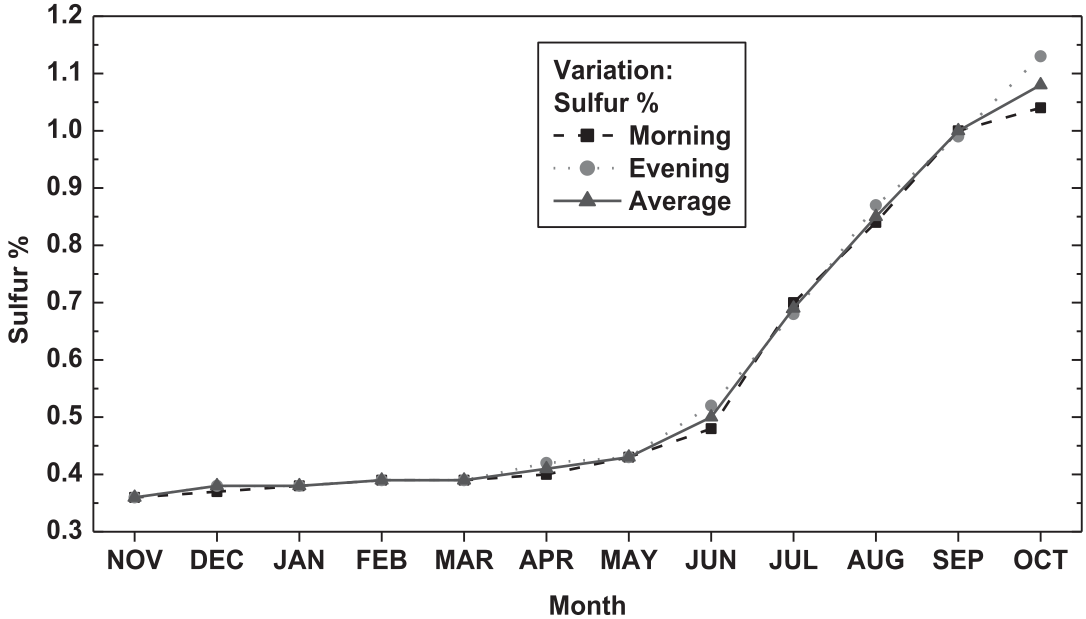


Figure 9: Month by month variation of sulfur content of the open air stockpile coal

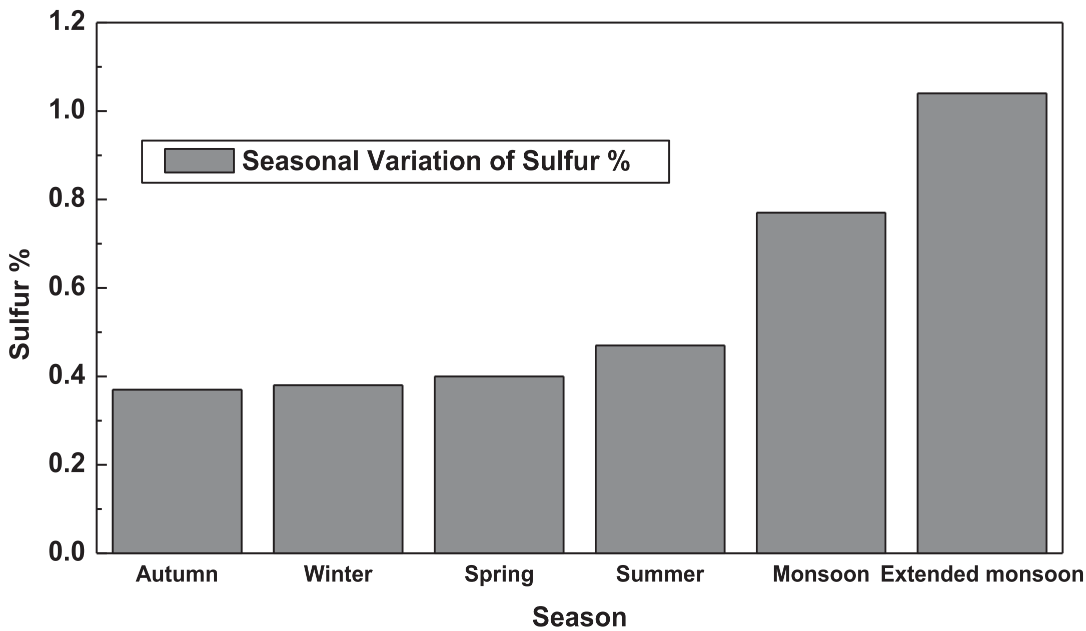


Figure 10: Seasonal variation of sulfur content of the open air stockpile coal

Release of heat increases the temperature of the coal bed which accelerates the oxidation. Since oxidation is an exothermic process with progress of aerial oxidation temperature of coal bed or stockpile progressively increases. The higher the temperature the greater is the rate of oxidation and of heat build-up. In the absence of heat dissipation that results into spontaneous heating of coal. Low rank coals when stockpiled are more susceptible to auto-oxidation and hence to spontaneous heating, and to combustion of carbon. Combustion could be partial or complete. Whether fire occurs or not the temperature increase and progressive reaction with atmospheric oxygen gradually impairs certain properties of the coal [4, 5, 6]. It has further been reported that during natural weathering processes, the organic materials on bituminous coal surface decreased while the inorganic materials increased. The organic materials would be oxidized further and a part of them would release gas components such as CO and CO_2 and water. The content of C-C and C-H groups decreased while the content of C-O, C=O and O=C-O increased after natural weathering processes of six months. Also decreased the surface C/ O atomic ratio from 2.66 to 0.88 [7].

Nitrogen content

Since nitrogen is almost entirely present in coal matter, its decomposition invariably leads to release of nitrogen as well. That explains similar trends in the decline of hydrogen and nitrogen content observed for the stockpiled coal. Fig. 7 indicates the nitrogen content to be decreasing from 1.32% in the month of November to 0.83% in the month of October next year. Similar to hydrogen content for the month of December, morning and evening samples show some difference. Seasonal decline of nitrogen content (Fig. 8) is as a result also quite similar to that of hydrogen content (Fig. 6).

Sulfur content

Quite significant is the change in sulfur content of the coal stockpiled in open air for a period of one year. It increased from 0.36%, a value typical for most of the Gondwana coal in India to 1.08%, a value that exceeds the sulfur limit of 1% imposed on internationally traded coal (Fig. 9). Sulfur content only nominally increased in the months of November through to March. In subsequent three months it kept on increasing, recording a sharp rise in the months of June to October. The trend gets reflected in the seasonal change in sulfur content (Fig. 10). It remains broadly same in autumn, winter and spring, then, rapidly increases in the next three seasons.

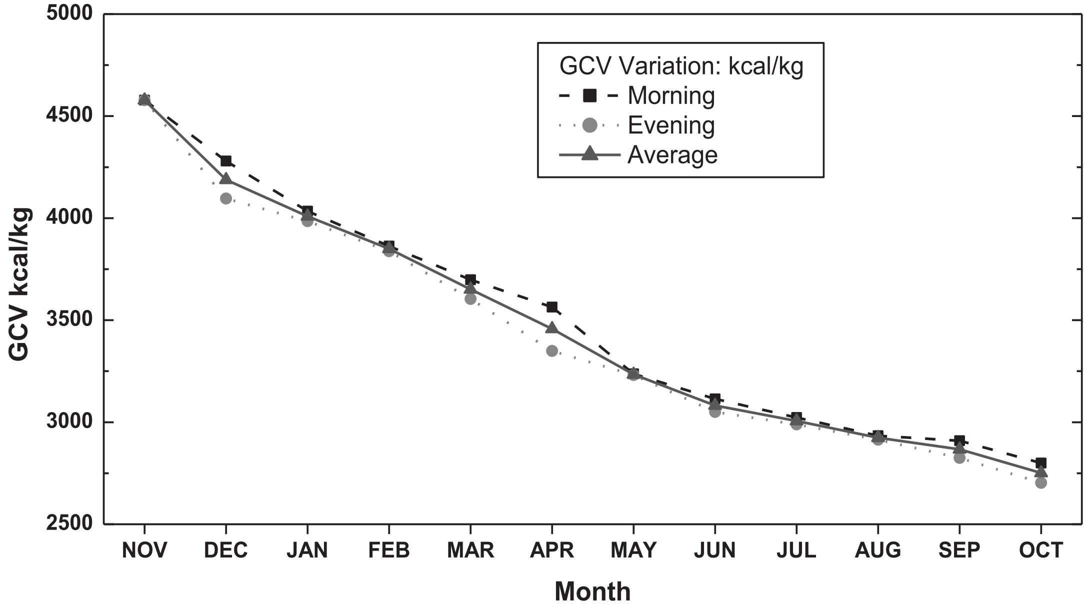


Figure 11: Month by month variation of GCV of the open air stockpile coal

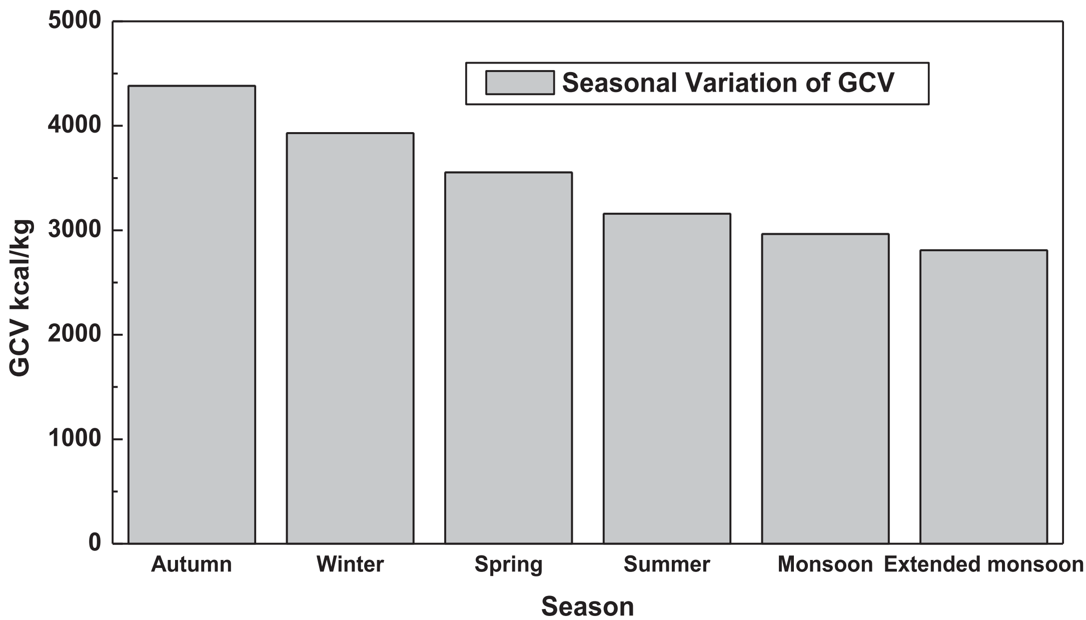


Figure 12: Seasonal variation of GCV of the open air stockpile coal

In coal stockpiles pyrite oxidation is probably a factor in the process of spontaneous heating for two reasons: (1) the reaction is highly exothermic (2) the associated coal is disintegrated during the reaction and that increases the amount of reactive coal surface exposed. Finer and more dispersed is pyrite in coal, more effective it is in promoting self heating. The dry oxidation of pyrite may be represented by the following

$$FeS_2 + 3O_2 \leftarrow\leftarrow\rightarrow FeSO_4 + SO_2$$

The ferrous sulfate formed may undergo decomposition to give

$$2FeSO_4 \leftarrow\leftarrow\rightarrow Fe_2O_3 + SO_2 + SO_3$$

Where there is moisture present a more highly exothermic reaction is favored [8]

$$2FeS_2 + 2H_2O + 7O_2 \leftarrow\leftarrow\rightarrow 2FeSO_4 + 2H_2SO_4 + 642 \text{ calories}$$

The reactions presented above explain why sulfur content (Fig. 10) remains broadly same in autumn, winter and spring, increases in summer, then, rapidly increases in the next two seasons. **Ultimate analysis results therefore provide conflicting requirement for a stockpiling strategy.** Sulfur content variation suggests that stockpiling can be done for a six month period covering autumn, winter and spring, whereas changes in carbon, hydrogen and nitrogen contents indicate that stockpiling should be restricted to not more than a month.

GCV Variation

It is well known that as a result of weathering calorific values of thermal coals are affected harmfully [2]. It has already been reported that carbon and hydrogen content of the stockpiled coal, both significantly contributing to its heat value, declined through the one year period due to the heat release on wetting because of the exposure of the coal stockpile to alternate rain + humid weather and sunshine + dry climate. In addition rise in sulfur content through highly exothermic reaction further contributed to the process of spontaneous heating. Both appear to have contributed to decay or disintegration of coal matter through incomplete or complete combustion, though no fire has been reported from the coal stockpile.

As a result GCV of the **relatively low rank coal** in stockpile decreased on month to month basis (Fig. 11) from 4578 kcal/kg for the month of November to 2751 kcal/kg for the month of October next year, a drop by 1827 kcal/kg equivalent to approximately six commercial grades. Seasonal decline of GCV of the coal in open air stockpile is observed for the whole one year (Fig. 12). This must be a major cause of concern. GCV results are in agreement with ultimate analysis results for carbon, hydrogen and nitrogen (Fig. 3-8). The GCV declining trend observed in case of this investigation is in line with a previous study carried out for a **high rank** North

Karanpura coal [3]. The said study reported a GCV drop of about 600kcal/kg in just five months covering summer and rainy seasons. **In addition to ultimate analysis, GCV results also suggest that stockpiling should be restricted to not more than a month.**

CONCLUSIONS

For the purpose of investigating the effect of natural weathering an open air approximately 500t stockpile of relatively low rank coal with no cover whatsoever was made at a power plant site located in Singrauli coalfield. Results of the study carried out for one whole year covering all the seasons clearly demonstrate an all round deterioration in quality of the stockpiled coal.

HGI dropped to the level of about 60 in summer, a reduction by approximately 25%, from the broadly consistent level of 80±5 for the remaining seasons. That made it a hard coal by both US and Indian nomenclature. Possibly because of oxidation of pyrite, sulfur content increased from 0.36%, a value typical for most of the Gondwana coal in India to 1.08%, a value that exceeds the sulfur limit of 1% imposed on internationally traded coal. The rise has been most significant in summer and monsoon months.

Because of decay and disintegration of coal matter, carbon, hydrogen and nitrogen contents steadily decreased from 52.5% to 34.2% 3.71% to 2.51% and 1.32% to 0.83%, respectively. As a result GCV of the relatively low rank coal in stockpile decreased from 4578 kcal/kg for the month of November to 2751 kcal/kg for the month of October next year, a drop by 1827 kcal/kg. Authors are aware that sampling and analytical errors might affect the GCV results. Nevertheless that might translate into a difference of 150x2=350 kcal/kg covering both ends of the spectrum. In that case the GCV drop would be, after rounding off, approximately 1500kcal/kg, which is large. Ultimate analysis and GCV results suggest that stockpiling should be restricted to not more than a month.

Let it be noted that results obtained and conclusion thereof drawn are coal and year-long ambience specific.

References:

1. H Ramakrishna, Coal Stockpiles In Indian Power Plants TCE Consulting Engineers Limited,
2. J W Leonard (Editor), Coal Preparation, 4th Edition, Chapter 1, pp 35-37, AIME, New York, 1977
3. D Banerjee, M Hirani, S K Sanyal, Coal Quality Deterioration in a Coal Stack of a Power Station, Applied Energy, 66 (2000), pp 267-275

4. Pis Jose, Puente G, de la Fuente E, Moran A, Rubiera F, A Study of Self-heating of Fresh and Oxidized Coal by Differential Thermal Analysis, Thermochimica Acta 1996, 273 pp 93-101
5. B K Mazumdar, A Banerjee, H C Nandi, Spontaneous Combustion of Coal: An Approach to the Problem, Fuel Science & Technology, 1983, 2 pp 93-102
6. K K Bhattacharya, The Role of Sorption of Water Vapour in Spontaneous Heating of Coal, Fuel, 1971, 50, pp 367-380
7. W Xia, J Yang, C Liang, Investigation of Changes in Surface Properties of Bituminous Coal during Natural Weathering Processes by XPS and SEM, Applied Surface Science, 293 (2014), pp 293-298
8. J W Leonard (Editor), Coal Preparation, 4th Edition, Chapter 16, pp 8-9, AIME, New York, 1977

Acknowledgement:

Authors gratefully acknowledge the financial and logistics support provided by National Thermal Power Corporation to carry out the investigation.

❋❋❋

Ensuring Environmental Sensitivity in New Project Development

Jayanta Bhattacharya, PhD
Professor, Department of Mining Engineering and School of
Environmental Sciences and Engineering
Member, State Environmental Appraisal Committee,West Bengal
Environmental Consultant :SAIL, Tata Steel, NTPC,WBPHED and many others
Indian Institute of Technology, Kharagpur-721302,India.
Also email: jayantab@mining.iitkgp.ernet.in

Introduction

This paper aims to evaluate the infrastructural provisions of a new project by studying the land use pattern and land use in relation to agriculture and project development which causes impact on biodiversity, hydrology, environment and people. Thus, it is evaluated to design a sustainable architecture and livelihood plan for all levels of people working the area.

In congruence with the global best practices, along with present skills and capacity of the developer, new design requirements propositions for sustainable land use and economic and modern layout plan in the existing plot is suggested.

Infrastructural Development

High-Performance Buildings:

Green building (also known as green construction or sustainable building) refers to a structure and using process that is environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition.

Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective is that green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving productivity
- Reducing waste, pollution and environmental degradation

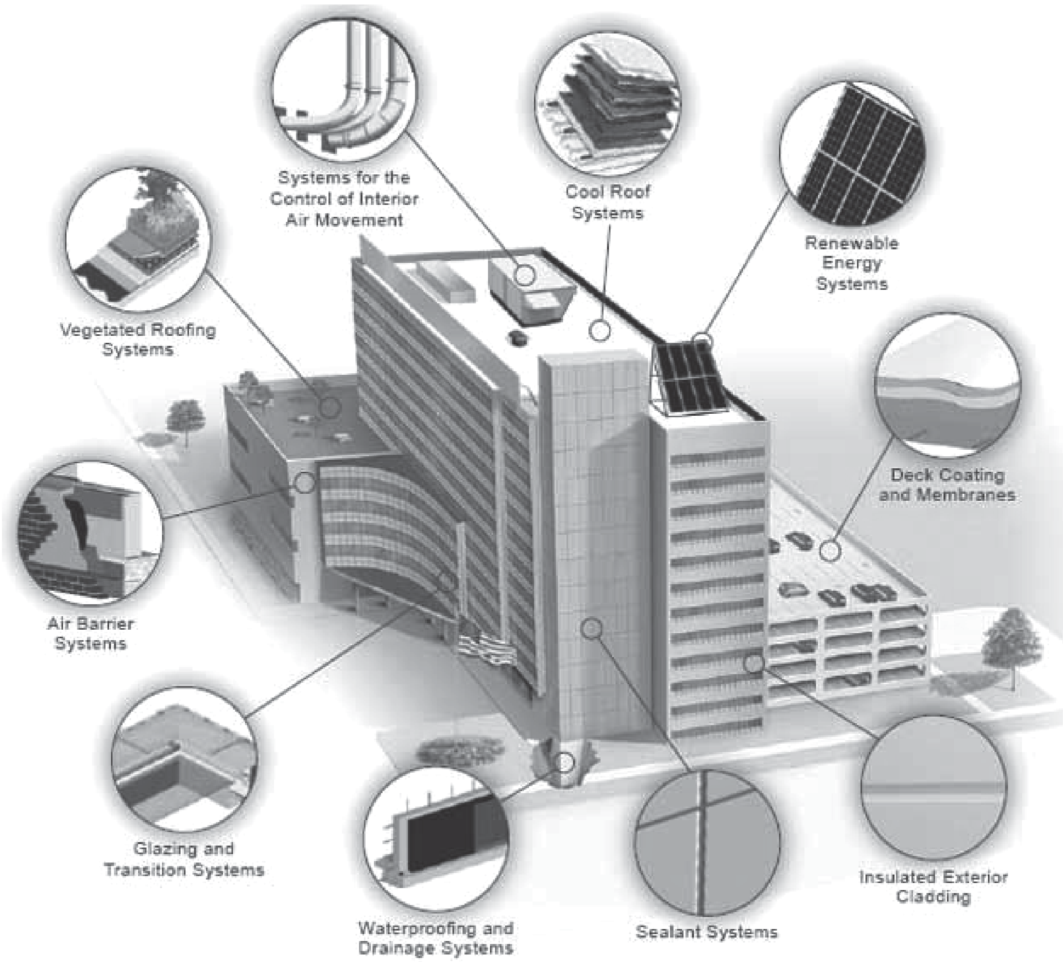


Figure 1. Some of the prominent features for sustainable design that can be incorporated in the township

Water Conservation

- To the maximum extent feasible, facilities should increase their dependence on water that is collected, used, purified, and reused on-site.
- Dual plumbing that recycles water in toilet flushing or by using water for washing of the cars. Grey water can also be used for irrigation and landscaping.
- Waste-water may be minimized by utilizing water conserving fixtures such as ultra-low flush toilets and low-flow shower heads.

Figure 2. Water conservation example

Waste Reduction:

- Centralized wastewater treatment systems can be costly and use a lot of energy. An alternative to this process is converting waste and wastewater into fertilizer, which avoids these costs and shows other benefits.
- By collecting human waste at the source and running it to a semi-centralized biogas plant with other biological waste, liquid fertilizer can be produced. This concept was demonstrated by a settlement in Lubeck Germany in the late 1990s. Practices like these provide soil with organic nutrients and create carbon sinks that remove carbon dioxide from the atmosphere, offsetting greenhouse gas emission.

Figure 2: Waste Management

Figure 3. Waste Hierarchy

Indoor Air Quality:

- This is to ensurecomfort, well-being, and productivity of occupants.
- Buildings should rely on a properly designed ventilation system(naturally or mechanically powered) to provide adequate ventilation of cleaner air from outdoors or recirculated, filtered air as well as isolated operations (kitchens, dry cleaners, etc.) from other occupancies.
- During the design and construction process, construction materials and interior finish products with zero or low VOC emissions should be chosen.

Adherence to LEED Gold rating:

- Leadership in Energy and Environmental Design (LEED) is a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes and neighborhoods.
- Buildings can qualify for four levels of certification:
  - Certified: 40–49 points
  - Silver: 50–59 points
  - Gold: 60–79 points
  - Platinum: 80 points and above

Zero Net Energy Buildings:

- Building with zero net energy consumption, meaning the total amount of energy used by the building on an annual basis is roughly equal to the amount of renewable energy created on the site. For example:

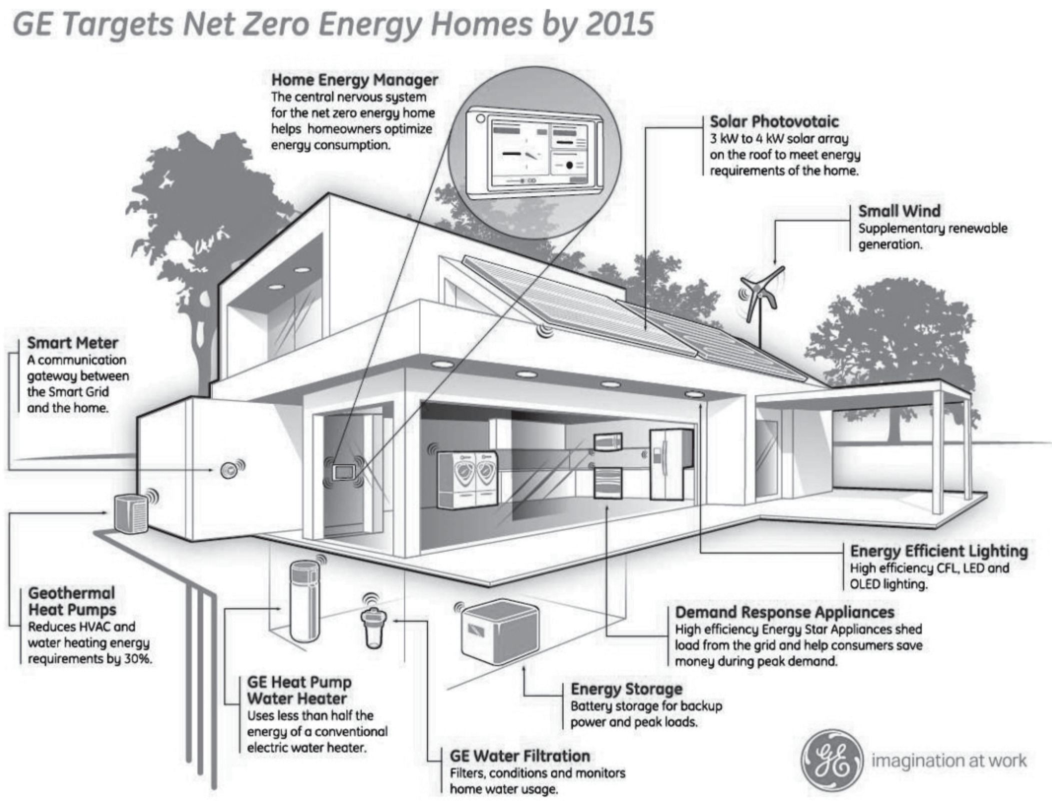


Figure.4Net zero energy homes

- ✓ **Energy efficient and LED lighting fixtures**
- ✓ **Zero wastewater discharge**
- ✓ **Means to tackle heat island effect with sufficient greenery and landscaping in the surroundings.**

Township Design Propositions

A few suggestions are made towards the architectural design of the buildings in the township depending on the built infrastructure requirement. It has emerged after discussions with the company that the township, and blocks especially Block – I, will host the following facilities:

- Residential Quarters
- Office
- Crèche and Dispensary
- Workshop
- Canteen and Rest shelter
- Utility infrastructure

Hence, the proposals for housing are made in three categories:

- **For Very-senior and Senior Level Executives:**
  Different housing styles are proposed for different levels of employees which are all vibration-resistant and structurally sound for the conditions that might be encountered in the vicinity of a site.
  Of this, for the highest order executives, 3BHK multi-story apartment blocks are proposed with 4 flats per floor. The buildings can be G+3 with a stilt floor for parking or common facilities. The figures below depict the ground floor plan, typical plan and structural plan respectively.
- **For Middle and Entry Level Executives:**
  A multi-storied block with 2BHK and 3BHK variants is proposed for a healthy mix of employees.
- **For workers:**
  Clusters of single-storied confined masonry houses are proposed for the workers.

Confined masonry is most suitable and practical method for construction of small houses in vibration areas. The level of engineering required is embedded in empirical rules for planning, design and construction of these houses. When the ground shakes moderately, unconfined walls are pushed sideways and therefore develop cracks. When the ground shakes violently, unconfined masonry walls collapse bringing down the roof, either partly or fully.

Two prominent features of confined masonry construction are:

- Use of a regular grid of walls in both directions with RC vertical members at all wall junctions and in straight walls of longer lengths, and RC vertical elements (toothed into the masonry wall segments) and RC horizontal bands (resting on the masonry walls of the whole house). These items together confine the wall segments and prevent them from dilating along the length direction of the wall and from falling out-of-plane along the thickness direction of the wall.
- Sequence of first making the masonry walls and then pouring in-situ the RC vertical elements and horizontal bands. This choice of construction sequence is responsible for enhancing the integrity of the masonry units and mortar in Confined Masonry, which in turn makes Confined Masonry Construction superior to regular RC frame buildings with plain masonry walls as in fills.

Why to choose Apartments over single Residences?

Land, if seen as a commodity, is getting scares day by day, one of the merits of constructing multistory residences it uses minimum land to provide maximum dwelling inclusive of the amenities, utilities and services. Following are the merits from the benefit of the residents' point of view

- **Low cost**

Apartment living can be much more cost effective than house living for both bills and rent. Heating or cooling a smaller area will save money on fuel and electric bills. The rent is usually much cheaper on apartments, compared a house or a mortgage. Apartments can also be quite a sustainable option because close proximity of multiple block or flats it means that apartments retain cool since less surface area is exposed to sun throughout the day, which reduces the amount of cooling you use in your own apartment. Fewer amounts of appliances and fittings are required in a flat which is why it is much cheaper than living in a house. The newer your building, the more energy efficient is likely to be.

- **Low Maintenance**

In an apartment, usually there is always a manager to deal with the problems and issues of the resident. Gardening is another major factor to consider. Most apartments don't have private gardens, only small balconies, which means that if living in an apartment, weekends can be spent doing whatever the resident wishes rather than maintaining the backyard and garden. The grounds of apartment blocks usually have a maintenance person who takes care of the communal building gardens.

- **Increased safety**

Most apartments have several layers of entry: a main door, a side door or a fire door, and the door of the apartment. It's more difficult for potential thieves to get access to your home in an apartment, particularly if your apartment has a foyer or secure front entry system. There's also the benefit of living in such close proximity to others. It's trickier for a thief to get large valuable items past several other apartments and out the communal front door without witnesses.

- **Extra Amenities**

Apartment blocks often come with amenities that you wouldn't normally get if staying in a private house, like gyms, pools, and rooftop entertaining areas, secure storage area. Having a gym and community garden or any common recreational area site is really convenient and saves money on membership fees. Terrace areas and common tot lots are great for entertaining and will save the residents from having to invest in expensive outdoor entertaining equipment for children. One of the best perks of apartment living is the car park. Street parking can be a nightmare and apartments often come with secure parking. Having a secure car park will probably save money in car repairs too. Parking a car on the street in an urban area can be really expensive but in remote areas the horrors of theft, dings and break-ins are prevalent.

- **Low Commitment**

Commitment to the property does not go away whether you are living in a house or a flat. But it is definitely low while living in a Flat.

Critical Impacts on Hydrology:

Hydrology includes surface and groundwater. During project development water is taken generally from both the sources of water (surface and groundwater). The acute effects of project construction on hydrology are as follows:

- Development can pollute the groundwater as well as the surface water by leaching. Groundwater is polluted by such inorganic ore.
- Surface water will be polluted by groundwater and surface water interaction.

Objectives of Sustainable Practice:

The project has the potential to affect biodiversity and water cycle or hydrology throughout the life cycle of a project, both directly and indirectly. Direct or primary impacts from a project can result from any activity that involves land clearance (such as access road construction, exploration drilling, and overburden stripping or tailings impoundment construction) or direct discharges to water bodies (riverine tailings disposal, for instance, or tailings impoundment releases) or the air (such as dusts or smelter emissions). Direct impacts are usually readily identifiable. Indirect or secondary impacts can result from social or environmental changes induced by operations and are often harder to identify immediately. Sustainable practice includes biodiversity conservation and water conservation. Benefit sharing approach leads to sustainable practices.

2.5 Worldwide best practices:

This good practice guidance encompasses the steps required to improve biodiversity management throughout the cycle. It assumes the existence of a corporate commitment to the ICMM sustainable development principles and sub-elements, which may be reflected in individual members' biodiversity strategies, policies or standards. Instead, it offers a series of practical modules that should enable companies to:

Understand the interfaces between their activities and biodiversity: Help companies recognize the interfaces between their various operational activities and biodiversity, and to engage effectively with stakeholders.

Assess the likelihood of their activities having negative impacts on biodiversity: Undertake practical steps to assess the potential for operational activities to negatively affect biodiversity and related stakeholders.

Mitigate potential impacts on biodiversity: Identify and implement a hierarchy of measures to protect biodiversity and affected stakeholders.

Explore the potential to contribute to biodiversity conservation: Beyond the mitigation of impacts, explore the potential to contribute to biodiversity conservation or protection.

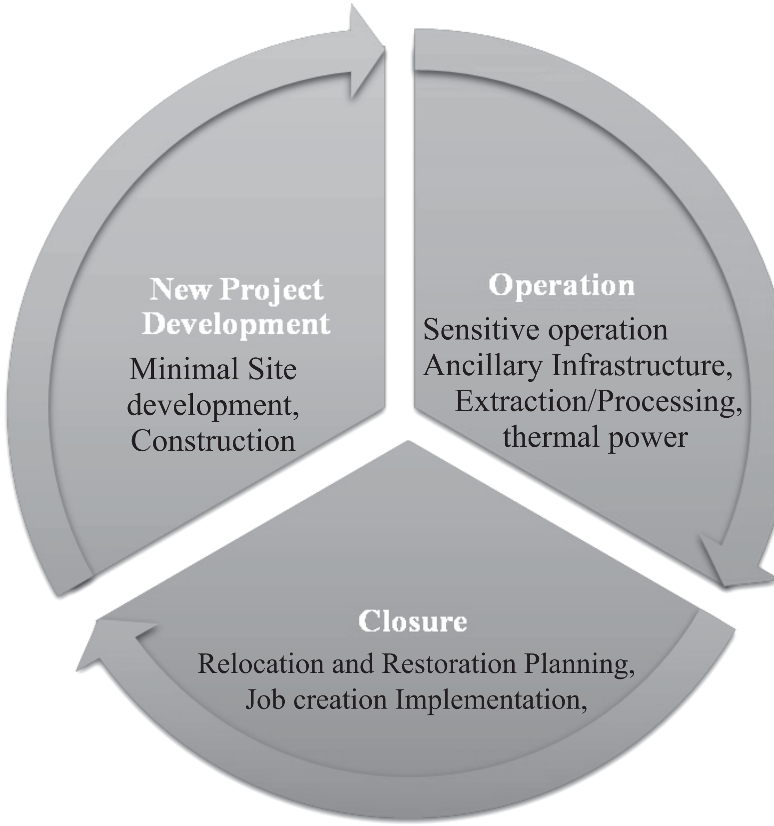


Figure 5: Integrating Biodiversity into the Project Cycle

The best practice for biodiversity conservation is divided into three parts. It highlights the importance of biodiversity and relevance to the sector, and emphasizes the need for stakeholder engagement in the identification, assessment, mitigation and management of biodiversity

2.6 Methods of Mitigation:

2.6.1 Mitigating measures to reduce impacts on biodiversity:

Mitigation is concerned with identifying and implementing measures to safeguard biodiversity and any affected stakeholders from potentially adverse impacts of and also to safeguard hydrology of that area. Ideally, the aim is to prevent adverse impacts from occurring or, if this is not possible, to limit their significance to an acceptable level. A number of categories of mitigation and a hierarchy of their desirability are illustrated below:

- Avoiding impacts by modifying a proposed project operation in order to prevent or limit a possible impact. The highest priority should always be afforded to avoidance measures.

- Minimizing impacts by implementing decisions or activities that are designed to reduce the undesirable impacts of a proposed activity on biodiversity.
- Rectifying impacts by rehabilitating or restoring the affected environment. This would include attempts at habitat re-creation, to restore the original pre-project land uses and biodiversity values.
- Compensating for the impact by replacing or providing substitute resources or environments. Compensatory measures should be used as a last resort and might include so-called offsets, such as purchasing an area of equivalent habitat for longer-term protection.

2.6.2 Mitigative measures for impacts on hydrology:

- Minimizing impacts on groundwater by regular monitoring of water level fluctuation to reduce the chances of hydraulic disequilibrium.
- Minimizing water extraction from high recharge zone. Water can be extracted from low discharge zone.
- Integrated watershed management can be developed to minimize the effect on down-streams. The water quality and quantity of all tributaries of one large river can be maintained.

2.7 Skill and Capacity of the Company:

A modern company should always endeavor to conduct its business responsibly, mindful of its social accountability, respecting applicable laws and with regard for human dignity. The CSR initiatives focus on biodiversity and hydrology are as follows:

- Undertaking plantations and afforestation activity
- Promoting renewable sources of energy
- Recharging ground water levels
- Conserving biodiversity and supporting research, awareness and advocacy on issues related to biodiversity
- Promoting awareness about environmental issues
- Promoting Gap Plantation

The area will be re-stocked by raising plantation @200 plants per hectare in ANR mode. Taking into consideration the site specific soul condition, existing species growing their naturally and the requirement of the local people, the following species are proposed to be planted in the area.

The main objective of the present scheme is to raise gap plantation in degraded forest as well as to retain soil and moisture conservation measures, restock and rejuvenate degrade forest within 100 m in the outer perimeter of lease.

Hence the main objective of the present regeneration scheme is as follows:

1. To afforest the degraded forest land and to restore the degraded forest lands by RDF plantation

2. Clearly, demarcating and fencing the area to dispense with the biotic interferences
3. To improve the micro edaphic conditions by undertaking suitable soil and moisture conservation measures
4. To protect the area against encroachment, illicit felling, fire incidences, grazing and all other forms of biotic interference and allow unhindered growth of the saplings.
5. To create awareness among the local villagers for protection and maintenance of plantation and the forest for ensuring enrichment of the ecosystem and replacement of the degraded areas with natural green cover.

Offsetting Methodology for No Biodiversity Loss

Habitat loss is the first cause of biodiversity loss, especially through accelerating urbanization, industrialization and infrastructure development. Although measures can and should not replace stringent actions to reduce threats to biodiversity, several countries require that developers first avoid biodiversity impacts, then minimize the impacts that cannot be avoided and, if there are any residual impacts, offset these through actions that generate an equivalent biodiversity gain, there or elsewhere. This hierarchy of avoiding > reducing > offsetting impacts is known as the mitigation hierarchy.

4.5 Business Case for a Biodiversity Offset

In summary, we believe that such an offset programme will bring about the following advantages:

1. Continuing access to land and capital;
2. Increasing investor confidence and loyalty;
3. Reducing risks and liabilities;
4. Strengthening relationships with local communities, government regulators, environmental groups and other stakeholders;
5. Building trust on a credible reputation for environmental and biodiversity related management performance and winning a 'social license to operate';
6. Increasing 'regulatory goodwill' which leads to faster permitting;
7. Influencing emerging environmental regulation and policy;
8. Developing more cost effective means of complying with increasingly stringent environmental regulations;
9. Taking advantage of 'first mover' benefits in the marketplace;
10. Maximising strategic opportunities in the new markets and businesses emerging as biodiversity offsets become more widespread; and
11. Improving staff loyalty.

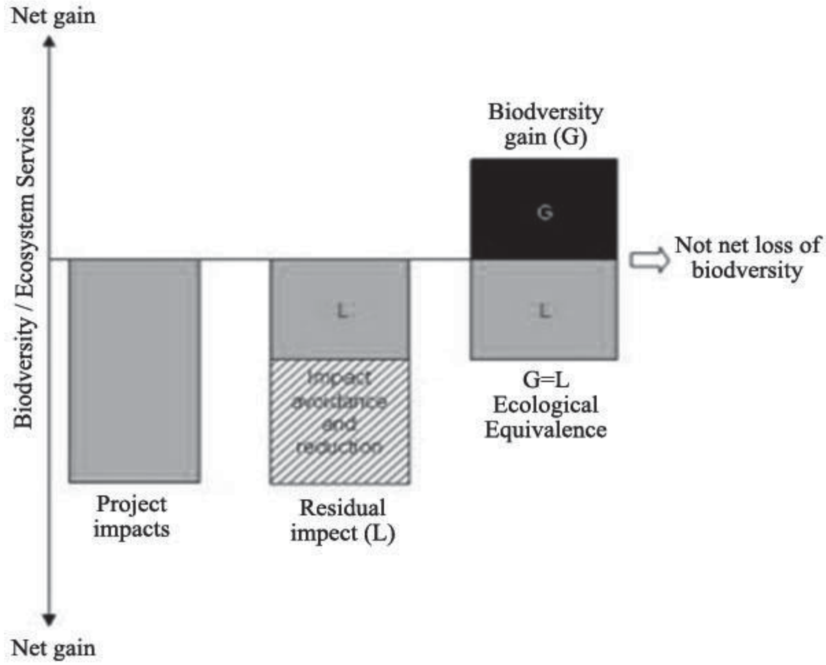


Fig.6. Graphical representation of biodiversity offsets as part of the mitigation hierarchy and of ecological equivalence in the context of no-net-loss.

We focus here on the specific issue of ecological equivalence and we identified several key points that require particular attention:
the definition of detailed target components of biodiversity and ecosystems (animal and plant populations, particular assemblages of species, community types, ecosystem properties, ecosystem services, etc.),
the development or selection of appropriate indicators (including landscape-level processes) and scoring procedures,
the identification of appropriate baselines for calculating losses and gains as well as the need to address,
time-related issues (e.g. delays between losses and gains) and
uncertainties in both assessment and offset outcomes.

4.3 Indicators

If the assessment of ecological equivalence is based on losses and gains (Figure.2) then selecting or developing appropriate indicators (or combinations thereof) and defining scoring procedures are necessarily central issues (e.g. Butler, 2009).

Offsets have often been sized on the basis of area alone, i.e. a given area of a habitat type destroyed leads to another area of the same type of habitat being either preserved or restored. Until recently, this was generally the case in wetland mitigation in the USA (Wilkinson, 2008; Hough and Robertson, 2009). This is a very crude approach to assessing losses and gains as it ignores variations in the "quality" or status of the species' habitat or habitat types that are impacted or used for offsetting. Several methods have refined this basic approach to incorporate additional criteria in the assessment of losses and gains (BBOP, 2009).

Under HEA and REA for example, a single proxy indicator is selected and scored as a percentage of a real or theoretical reference (benchmark) (Dunford et al., 2004). The choice of this proxy is essential to the outcomes of the method (Strange et al., 2002) and remains one of the method's main drawbacks because of the simplifying assumptions necessary for selecting a single proxy (Dunford et al., 2004). This difficulty could be solved by considering several candidate indicators and favouring that which gives the highest offset requirement. Alternatively, the single HEA/REA proxy can be an index that combines several indicators.

Some methods require that indicators be developed on a case-by-case basis, such as the amount of habitat required to support a breeding pair of animal species or a wetland unit along with its supporting uplands, as under US conservation banking (Madsen et al., 2010) or under the Ausgleich procedure of the German Eingriffsregelung policy (Bruns, 2007). Ad-hoc indicators are also developed for offsetting residual impacts on the integrity of the Natura 2000 network of protected areas under the European Habitats directive, as in the case of impacts on shorebirds in the UK (Morris and Gibson, 2007, Dodd, 2007).

Other methods use predefined indicators or scoring methods to assess losses and gains, such as the habitat-hectares method developed in the Australian state of Victoria for native vegetation (Parkes and Lyon, 2006 and Gibbons and Lindenmayer, 2007). It uses a set of indicators that describe site condition (species composition, structure, recruitment potential, invasive species, etc.) and its landscape context. They are weighted and combined into a habitat score (Parkes et al., 2003). Habitat-hectares are obtained by multiplying a site's habitat score by its area and they form the unit on which losses and gains are made equal. The habitat-hectares method offers a broad-brush assessment of a site's "quality" in terms of biodiversity in general or "naturalness" as do many of the scoring methods developed in the context of wetland mitigation in the USA and Canada (Fennessy et al., 2007). Habitat hectares can be complemented using an index of conservation significance (at a regional level) to generate a Biodiversity Benefits Index (BBI) (Oliver et al., 2005). Regional conservation significance is one way to define the area within which offsets must be implemented, together with considerations pertaining to e.g. species' mobility or "serviced" populations in the case of ecosystem services. The habitat-hectares method has been widely adopted in Australia: e.g. Biometric in New South Wales (Gibbons et al., 2004 and Cawsey and Freudenberger, 2005) and Biocondition in Queensland (Eyre et al., 2008). It has also inspired some of the recommendations of BBOP (2009) and Treweek (2009) concerning the use of multiple indicators and reference sites.

The habitat-hectares method uses reference sites (benchmarks) against which focus sites are assessed. Benchmarks are specific to each vegetation type in each biogeographic region (Parkes et al., 2003). Real sites are also used as benchmarks in several wetland mitigation methods such as DERAP in Delaware (Fennessy et al., 2007) but indicators can also be scored against "theoretical" references such as tables of presence/absence of species (e.g. habitat types defined by species lists) or quantitative values for measurable variables. Scoring of indicators against common references contributes to greater homogeneity among assessors, but see Cole (2006) and Stander and Ehrenfeld (2008) for a critique of the possible biases associated with reference selection in the context of wetland mitigation.

In some areas of Germany, a point-based system (Biotopwertverfahren) is used to assess site "quality" under the Ersatz procedure where offsets have to be spatially connected to impacted sites but only functionally "similar" (Louis, 2010). Different habitat types ("biotopes", defined using established typologies: Biotoptypenlisten) are assigned points according to their "ecological value" which enables comparisons between biotopes in a given typology (Bruns, 2007). This point-based approach can be enhanced by taking into consideration variations in quality within a habitat type, e.g. according to location or the presence of certain species or ecosystem-level properties. There are no national or regional guidelines on how points should be assigned and these vary considerably, which makes comparisons difficult (Bruns, 2007, Darbi and Tausch, 2010).

For some species, detailed knowledge can be used to take into account a site's location in assessing gains and losses (e.g. on dispersal or the combinations of habitat and patch sizes necessary for reproduction or wintering – Bruggeman and Jones, 2008). When such knowledge is unavailable, more general metrics can be used. As an example, Parkes et al. (2003) proposed simple measures of distance between patches in the Australian habitat-hectares method. Geographical Information Systems make indicators of landscape structure easy to use when assessing ecological equivalence on the basis of habitat types.

As this section shows, although the assessment of losses and gains requires the use of indicators, these can be designed and used in very different ways. Indicators can be developed specifically for a given impact or predefined. Some methods use established benchmarks and some allow out-of-kind offsetting by using correspondence tables between indicators and scores. Many methods ignore the landscape context.

Conclusions

In view of the above mentioned factors, a complete long term master plan for and restoration of the livelihood of people, method of mitigation and world wise best practices for restoration and resettlement and commitment of Tata's for wellbeing of environment around the project area and their long term plan for its mitigation Comparative study of existing mine plan and future mine plan is observed on five different blocks for efficient and sustainable use of land. Not only this but the master plan also suggests different important factors like waste minimization and OB dump reclamation for sustainability in plan development. Similarly, to make the township environment friendly and maintain ecological balance different environment management plan is suggested in and around lease area. They are Solid Waste Management: Air Pollution Control, Water Management, Water Pollution Control, Ambient Noise Control, Control of workplace vibration, noise, dust and fly rock generation due to blasting etc. Vegetation/ plantation Integrated land use Planning involving mine, township and other civic and rural areas. Occupational safety and health, Socio-economic measure risk assessment and Disaster Management were also studied.

Thus, last but not the least to successfully implement the designed and propositioned plan interaction between three major stake holders i.e. industry, community and government to make the designed sustainable and energy efficient township.

References

1. Apfelbeck, R., Farris, E., 2005. Montana Wetland Rapid Assessment Method Guidebook (Version 2.0).
2. A. Balmford, W. Bond, Trends in the state of nature and their implications for human well-being, Ecology Letters, 8 (2005).
3. Bean, M., Kihslinger, R., Wilkinson, J., 2008. Design of US Habitat Banking Systems to Support the Conservation of Wildlife Habitat and at-risk Species.
4. T. Bendor, A dynamic analysis of the wetland mitigation process and its effects on no net loss policy Landscape and Urban Planning, 89 (2009).
5. T. BenDor, N. Brozović Determinants of spatial and temporal patterns in compensatory wetland mitigation, Environmental Management, 40 (2007).
6. Boyd, J., Wainger, L., 2003. Measuring Ecosystem Service Benefits: the Use of Landscape Analysis to Evaluate Environmental Trades and Compensation.

7. S. Brownlie, M. Botha, Biodiversity offsets: adding to the conservation estate, or 'no net loss'? Impact Assessment and Project Appraisal, 27 (5) (2009).
8. D.J. Bruggeman, M.L. Jones, Should habitat trading be based on mitigation ratios derived from landscape indices? A model-based analysis of compensatory restoration options for the red-cockaded woodpecker, Environmental Management, 42 (2008).
9. D.J. Bruggeman, M.L. Jones, F. Lupi, K.T. Scribner, Landscape equivalency analysis: methodology for estimating spatially explicit biodiversity credits, Environmental Management, 36 (2005).
10. D. Bruggeman, M. Jones, K.T. Scribner, L. Frank, Relating tradable credits for biodiversity to sustainability criteria in a dynamic landscape, Landscape Ecology, 24 (2009).

❋❋❋

The Recent Trends Transforming the Power Sector

Joy Chakraborty
Divisional Engineer, WBREDA

From the decline of coal power to the rise of energy storage, big changes are taking hold in the power sector across the globe .By now, the utility industry is on the brink of a massive transformation. Analysts told us this would happen — the traditional power sector model would be upended and utilities would need to adjust their business models to operate in a new energy future. Now, with plummeting prices for renewables and energy storage and the proliferation of distributed energy resources, changes are taking hold faster than many expected. Here we are discussing on the top five trends that transform the power sector across the globe.

1. Coal power in decline:

For many power companies and policy analysist, the single most noticeable trend in the utility industry is the steady retirement of coal-fired power plants.

In the United States of America, about 25,000 MW of coal capacity has been retired since 2009 and there are already formal plans to retire about the same amount of coal capacity by 2022. Of those retired plants, most were nudged into unprofitability by historically low natural gas prices .A push for renewables and other clean resources instead of new coal is noticed for recent days. The trend in India is almost in the same line.

2. Natural gas is growing fast

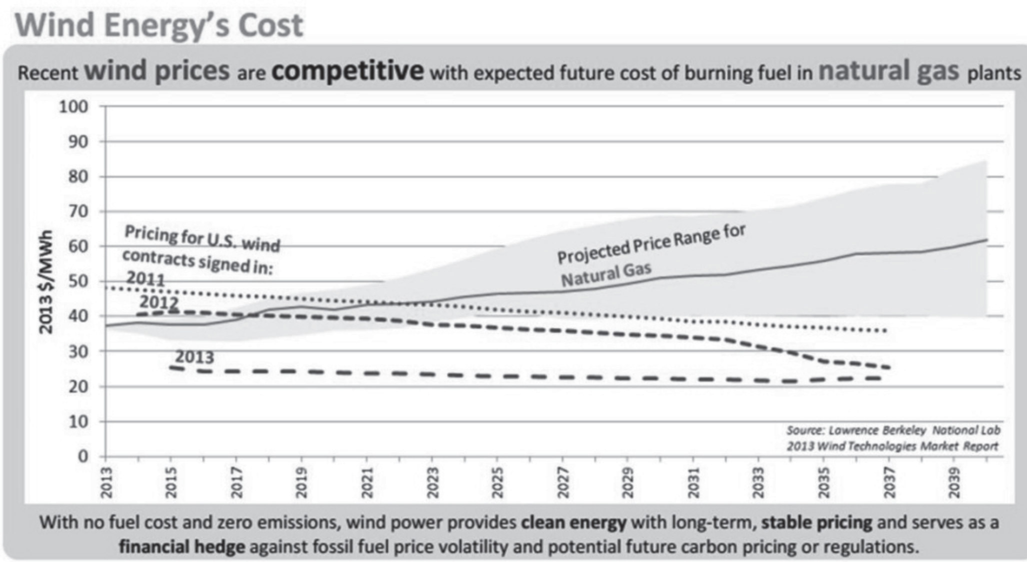
In the near-term, coal's loss appears to be natural gas' gain. As market conditions and regulations push older coal generators into retirement, utilities looking to add reliable capacity quickly are increasingly looking to gas based plants.

3. Renewable reaching grid parity

For years, the primary argument against renewable energy was that it isn't cost effective. Today, that line of reasoning is becoming increasingly obsolete. In many regions, wind and solar — especially at utility scale — are reaching grid parity and often pricing out more traditional generation resources.

For renewable energy observers, this trend isn't new to 2017. According to the financial firm Lazard's annual study of global energy costs from a variety of fuel sources, it is found that for utility-scale projects, both wind and solar are cost-competitive with traditional generation technologies without subsidies and face fewer regulatory hurdles, market uncertainties than new nuclear or "clean coal" plants. Deutsche Bank expects solar energy to reach grid parity in at least 6 countries in the world in 2019.

Wind energy is also making waves in regional markets. Analysts credit cheap wind, along with natural gas, for pushing a host of older nuclear and coal plants to unprofitable status in deregulated markets.



Source: Southeastern Wind Coalition, U.S

4. Utilities face growing load defection:

Globally, in the last three years, distribution utilities are struggling with how to deal with load defection as some customers bypass their local utility for their electricity needs.

Part of that is due to the rapid proliferation of rooftop solar, especially in a few select markets such as metro cities. According to researchers, in India, residential solar grew 30% in the second quarter of 2016 over where it was during the same period in 2015. While rooftop solar penetration is increasing, demand-side management and energy storage technologies are on the verge of making it easier for consumers to move their electricity demand to times when electricity prices are lower, at least under certain rate structures. It calls "demand flexibility," the combination of these load management strategies with rooftop solar installations, especially in locations and sectors with high electricity costs, could lead a larger number of customers to purchase less power from their utility.

Source: Prayas Energy Group, Pune

5. Utility business models are changing

If each of above trends has something in common, it's that they all are changing the way power utilities have traditionally done business.

For most of the 20th century, the role of the utility was quite clear: Build out the grid and power generation system as a regulated monopoly entity to achieve economies of scale, and then maintain it so the lights don't go out. Utilities appealed to regulators when they needed new infrastructure, and then built it while earning a modest return. Fast forward to today and much has changed. Exactly how utility business models will transform will depend on location and regulation.

How utilities will make business in the 21st century remains to be seen, but one thing is for sure — they don't expect to preserve their old business models for long.

Deregulated Reactive Power; Minimising Loss, Helping the Environment

Niladri Chakraborty and Shyamasree Biswas (Raha)
Department of Power Engineeing,
Jadavpur University 2nd Campus
Kolkata 700098

It is now clear that non-conventional power generation is gaining huge attention from the business and environmental sustainability. But in the same token it is also an accepted fact that we can't set aside conventional coal based generation completely in near future due to competitive energy market. In deregulated power scenario, the real power loss minimisation aspect with voltage stability is a prime issue which are hindered by several uncertainties. Voltage profiles of the networks fluctuate frequently due to occurrence of bilateral and multilateral power transactions between the power suppliers and consumers in the deregulated power network. However, these transactions occur under certain rules and regulations as fixed by the individual system operator and the participants. In practical situations, the participants are frequently found to violate the contract of power trading causing the power mismatch either at the supplier's or consumer's side. This further leads to fluctuation of the security constraints in the form of load bus voltage profile of the network nearly at their marginal values. Even sometimes it disrupts the prefixed stable margin which causes increasing current flow and power losses. This situation requires adequate reactive power support for fixing the system voltage profile and real power loss minimisation.

The real power loss minimisation aspects with voltage stability have been already solved by incorporating tap changing transformer and reactive power compensations in terms of shunts capacitors since long back. Although, these type of compensators do not always offer effective as well as economic response to satisfy the steady-state and dynamic performances in a deregulated power scenario. In this context, the incorporation of different advanced *var* compensators likely the flexible AC transmission devices (FACTs), super conducting magnetic energy storage device, distributed generators (DG) and some of their combinations with capacitor have been found working economically efficiently in the power network, The loss minimisations with dynamic voltage limit crossover issues for power transactions are efficiently handled by these types of advanced *var* compensators. But, due to the high installation and operating costs, these advanced *var* compensators have restricted applications in developing countries. However if these are chosen with optimisation, the economics of incorporation of such devices may be competitive for the deregulated power network in the developing economics with special emphasis on environmental sustainability. The studies on these reactive power optimizations by advanced compensators are therefore gaining major interests in deregulated power scenario primarily by soft-computing methods. Again in many developed countries their use is already in vogue.

Since, the fundamental as well as deregulated power flow studies are non-linear, non-convex, non-differentiable optimization problems, soft-computing methods are found to work satisfactorily for them for initial developments of clear understandings. Amongst these soft-computing techniques, simulated annealing (SA), particle swarm optimisation, differential evolution, cultural algorithm, genetic algorithm have shown significant contributions. Even few advanced meta-heuristics techniques such as cuckoo search algorithm, grey wolf optimiser, whale optimization algorithm, ant lion optimiser, and chaotic krill herd algorithm are also applied to solve the proposed problem. Now, all these techniques work efficiently within a limited zone. To get improved performances, the hybrid applications of the techniques are also frequently utilised to solve the proposed problem. This helps to search the population space extensively to obtain the global convergence. Thus by choosing appropriate soft-computing methods, the *var* compensators are optimised and utilised to solve the loss minimisation issues for different scenarios.

Now from the above discussion, it is clear that *var* compensation reduces real power losses in the existing network. If the real power loss is minimised, in turn the burden of extra real power generation to compensate this loss will be reduced. In conventional optimal power flow models the generation reduction helps the environment by emitting less polluting agents due to burning of fossil fuel. Thereby, proper *var* compensation has a great impact on the environment sustainability. In this regard the pricing of *var* compensation is important particularly in the deregulated electricity market to assure the secured and improved power system operations. The pricing of *var* compensation in deregulated power scenario also influences the total economics of the network. The total economics is comprised of the economics of the *var* compensations, profit due to double auction bidding of the different participants of the proposed transactions, hourly spot pricing as applied by the transaction authority due to power mismatch during the power trading etc. The improved economics due to incorporation of the *var* compensators in the power network, is termed as reduced merchandising surplus. This is represented by the difference between the net incentive returns due to loss minimization and the costing of the proposed *var* compensator. For advance var compensators this necessitates further research. Therefore, as much as power loss minimisation will incur due to *var* compensation, overall economics of the network will improve with lesser SPM and GHG burden at least for the conventional coal based generations which still support the base load in the Indian context. These require closer investigations during solutions of *var* compensations in deregulated environment from the view point of the business and environmental sustainability.

In deregulated power scenario, the reactive power business is considered as ancillary service provider for the security and reliability of a power system. In deregulated markets reactive power as ancillary service is served as voltage regulation and reactive power spinning reserve. While procuring these facilities in the competitive power market, the system operator identifies the appropriate node for voltage support or reactive power requirements, and allocates the suitable providers in the required locations. The main objective of ancillary service provider in a deregulated power market is to enable transmission operator to secure reactive power service in a long term contract from the critical *var* providers. These reactive power producers are agreed to provide minimum *var* service on a payment basis while maintaining system voltage stability and minimising line losses for normal and emergency states. In this regards, microgrids may provide several advantages regarding their development as ancillary service providers in the distribution systems with lesser environmental burden. Amongst the microgrid performances such as the reactive power/voltage control, active loss balancing and demand interruption, the reactive power/voltage control is gaining major importance in the day-ahead market. The microgrid oriented reactive power bidding are procured in the deregulated power market through microgrid central controller (MGCC) and the market system operator. In this economic reactive power dispatch operation, the MGCC plays a vital role to verify the technical feasibility in terms of voltage magnitude and branch flow limits including line losses.

❄❄❄

Renewable Energy Potential of India : A Review

Dr. S. Biswas, Director,
BITM, Santiniketan— A Unit of CAMELLIA Group.

In India, energy supply is composed of a wide variety of energy resources; however, not all energy resources have the same environmental benefits and costs.

Green power is a subset of renewable energy and represents those renewable energy resources and technologies that provide the highest environmental benefit. EPA defines green power as electricity produced from solar, wind, geothermal, biogas, eligible biomass, and low-impact small hydroelectric sources. Customers often buy green power for its zero emissions profile and carbon footprint reduction benefits.

Renewable energy includes resources that rely on fuel sources that restore themselves over short periods of time and do not diminish. Such fuel sources include the sun, wind, moving water, organic plant and waste material (eligible biomass), and the earth's heat (geothermal). Although the impacts are small, some renewable energy technologies can have an impact on the environment. For example, large hydroelectric resources can have environmental trade-offs on such issues as fisheries and land use.

Conventional power includes the combustion of fossil fuels (coal, natural gas, and oil) and the nuclear fission of uranium. Fossil fuels have environmental costs from mining, drilling, or extraction, and emit greenhouse gases and air pollution during combustion. Although nuclear power generation emits no greenhouse gases during power generation, it does require mining, extraction, and long-term radioactive waste storage.

Benefits of Using Green Power

Conventional electricity can be a significant source of air pollution and greenhouse gas emissions. Switching to green power can help improve the environmental profile of your electricity use, while also providing other valuable benefits. Using green power helps to:

- Support renewable energy development (either directly or indirectly)
- Reduce the carbon footprint associated with your purchased electricity
- Hedge against future electricity price increases and volatility (certain products)
- Using of renewable energy encourage the generation of de-centralised power which reduces transmission losses

For organizational users, green power can:

- Serve as a brand differentiator
- Generate customer, investor, or stakeholder loyalty and employee pride
- Create positive publicity and enhance your organization's public image
- Demonstrate civic leadership

India has accounts for 5.2% of global share in electricity generation. But its per capita electricity consumption is only 770 kWh, which is lower compared to many countries, though electricity tariff is cheaper in India. Energy is the basic input in all sectors of the nation's economy, and the standard of living is directly related to per capita energy consumption. The commercial energy inputs to the Indian economy are from conventional sources like coal, hydroelectricity and nuclear energy. The country currently has total installed capacity of thermal 66% (approx.), hydroelectric 16%, nuclear 2% and renewable 16%. For long-term sustainability, minimum utilisation of fossil fuel for energy and maximum utilisation of renewable energy are to be considered. At the same time, minimum losses during generation transport and utilisation sector is also important. It is expected that 175 GW renewable energy will contribute to approximately 19% of entire power consumption in India at 2022.

In 2015, the distribution of U.S. renewable consumption by source was:

- Hydropower 25%
- Biomass Wood 21%
- Biomass Waste 5%
- Biomass Biofuels 22%
- Wind 19%
- Geothermal 2.5%
- Solar 5.5%

Renewable sources and their potential for supplying electricity

Renewable resources are those resources which can be used to produce energy and energy again e.g. solar energy, geothermal energy, tidal energy etc. Renewable resources are renewed by nature again and again and their supply was not affected by the rate of consumption. Wind, biomass hydro etc. are also considered as renewable resources. Non conventional energy resources which are considered for large scale use after the oil crisis of 1973 are called non-conventional energy sources/Renewable energy sources.

Renewable energy sources are all essentially based on the direct or indirect use of solar energy. The only exception is tidal energy, which essentially derives its power from the interaction between the earth and the moon.

Renewable energy can replace conventional fuels in the distinct areas like electricity generation, water heating, space heating, motor fuels, and rural energy services. The important renewable energy sources, which can be utilised for generating electricity in our country are as follows: (i) solar energy (direct): Solar thermal power and solar photovoltaic (PV) power, Solar energy (indirect), (ii) Hydroelectric power (large and small units); (iii) Wind energy (on land and offshore), (iv) Biomass power, (v) Wave energy, marine currents, and ocean thermal energy conversion (vi) Tidal energy.

Over the years, renewable energy sector in India has emerged as a significant player in the power generation capacity. Power is one of the most crucial components for the economic growth and welfare of nations. The existence and the development of adequate power sector are essential for sustainable growth of the Indian economy. India's power sector is one of the most diversified in the world. Sources of power generation range from conventional sources such as coal, lignite, natural gas, oil, hydro and nuclear power to viable non- conventional sources such as wind, solar, agricultural and domestic waste. The demand for the electricity in the country has increased rapidly and is expected to grow further in the coming years. In order to meet this increasing demand for electricity in the country, massive addition to the installed generating capacity is required. There has been a visible impact of renewable energy in the Indian economy during the last five years. Renewable energy sector in India has experienced tremendous changes in the policy framework during the last few years. Mainly, the solar energy and Wind energy sectors are experiencing accelerated and ambitious plans to increase the contribution of these sectors out of the total energy contribution in India.

India has an estimated renewable energy potential of about 900 GW from sources like Wind – 102 GW, Bio-energy – 25 GW, Small Hydro – 20 GW and Solar power – 750 GW. Renewable energy enjoys 15.90% shares in total installed capacity in India. As of March 2017, renewable energy installed capacity totaled to 57,700 MW. Renewable energy has been witnessing over 20% growth in the last five years. From the total renewable power installed capacity of 14,400 MW at the beginning of 2009, it has increased to the capacity of 38,822 MW at the end of December, 2015. It has also increased to the capacity of 45924 MW as on March, 2016 to 57,700MW by March, 2017. Wind energy continues to dominate India's renewable energy industry accounting for 29151.29 MW by March, 2017 from 25,088 MW by December, 2015.
Estimates of wind energy potential indicate that its potential is much higher across Gujarat and Tamil Nadu. Whereas, the solar energy potential indicate that it's potential is much higher across Jammu and Kashmir and Andhra Pradesh.

Solar thermal power and PV power

In general, the energy produced and radiated by the sun, more specifically the term refers to the Sun's energy that reaches the earth. Solar energy is utilised for direct thermal applications and for solar-electric applications. Solar thermal applications include water heating, space heating, drying, cooking etc. Generation of electricity is possible in solar thermal-electric power plants. These plants use concentrating collectors to collect the sun's energy at high temperatures and use this energy to generate high-pressure steam. The steam in turn is used in a conventional Rankine cycle to generate electricity.

Photovoltaic conversions are also a direct method of utilising solar energy, which makes use of solar cells to convert solar energy directly into electrical energy.

The electrical energy requirement for localised use in the remote locations all over India is estimated at about 11,000 MW – a substantial part of which is expected to come from PV systems that are not connected to the grid. These systems may be located as far as possible on rooftops, so that no land space is used. India has total installed capacity of almost 4101.68 MW grid-connected PV power systems having small capacities.

India has achieved a major milestone in solar power capacity addition. Cumulative solar capacity, including rooftop and off-grid segments, has crossed 10,000 MW in the country."The pace of sector activity has picked up tremendously in the last two years because of strong government support and the increasing price competitiveness of solar power," according to a report by Bridge to India, a global solar energy consulting firm. The government originally envisaged developing 20,000 MW of solar park capacity by 2020, but the scheme has received an enthusiastic response from the private sector and the government is already planning to double this capacity to 40,000 MW and a total of 100,000 MW by 2022. Further, eight green energy corridors are under construction, with financial assistance from German development bank KFW, to evacuate and integrate the growing share of renewable energy into the grid. The corridors will allow transmission of solar power from the solar rich states to other states.

Hydroelectric power

In hydro-electric plants energy of water is utilized to move the turbines which in turn run the electric generators. The energy of water utilized for power generation may be kinetic or potential. The first Hydel Power Station (HPS) implemented in India was Sidrapong one in Darjeeling (West Bengal) completed in 1897 and is still in operation. Hydropower technology is well-proven with efficiency rates which could go up to 90% depending on the design power. The depreciated Hydro Power Stations i.e. Pong on Beas River and Bhakra on Satluj River are currently selling power @ 18 and 28 paise/unit respectively. However, the advantages of longevity and cost of generation doesn't reflect in trends in India's energy mix which is dominated by thermal power (70% share). Hydro, with an installed capacity of 42,783 MW, has a share of around14% in 2016 coming down from 46% in1966.The plummeting share of hydro in the overall power portfolio is primarily attributable to the consistent non-achievement of targets. Out of 10,897 MW of target capacity addition as per 12th Plan, only 3811 MW has been achieved, which indicates that only one-third of the target was achieved during the first two-thirds of the period. The same trend was observed in the previous 11th Plan wherein only 40% of the target was met.

The present installed capacity is approximately 40,661.41 MW, which is 16.36% of total electricity generation in India and small hydro power capacity is 4101MW.

India has huge hydro potential of about 84,000 MW at 60% load factor, which can be economically exploited. Almost 49 large hydropower projects are under construction in India, which will be completed by the year 2022 with a cumulative capacity of 15,006 MW.

Wind energy

When the wind is blowing it exerts two types of force, lift and drag, on the objects in its path. Drag for acts in the same direction as the wind while lift is perpendicular to the direction of the wind. The relative sizes of the drag and lift forces depend entirely on the shape of the object.

India has great potential of wind energy to project as an alternate source of energy. Electricity can be generated from wind power by converting the kinetic energy in the wind into mechanical energy utilising wind turbines. The energy in the wind is utilised to turn propeller shaped blades around a rotor, which when connected to the main shaft can spin a generator to produce electricity.

The estimation of the potential wind resources in India is 102,788 MW assessed at 80m Hub height. The installed capacity of wind power in India was 22,645 MW as of 30 March 2015. The target set for wind power generation capacity is 60,000 MW by the year 2022. The preliminary assessments along the 7,600 km long Indian coastline have indicated prospects of development of offshore wind power as the wind speeds offshore are usually higher and steadier.

India had a record year and was the fourth largest market globally both in terms of cumulative capacity and annual additions last year. 3,612 MW of new wind power was added to reach a total of 28,700 MW at the end of December 2016. This total has risen to 31,177 MW at the end of March 2017. The total renewable energy capacity installed in the country crossed the 50 GW mark at the end of 2016. Among renewable, wind power accounted for over 57 percent of the installed capacity. India's wind power installations accounted for a 6.6 percent share of the global market in 2016.

Energy from biomass

Biomass is a renewable source of **fuel** to produce energy because: waste residues will always exist – in terms of scrap wood, mill residuals and forest resources; and. properly managed forests will always have more trees, and we will always have crops and the residual biological matter from those crops. Biomass contains stored energy from the sun. **Plants** absorb the sun's energy in a process called **photosynthesis**. When biomass is burned, the chemical energy in biomass is released as heat.

Biomass fuels can be most efficiently used when generating both power and heat through a combined heat and power (or cogeneration) system. A total of 288 biomass power and cogeneration projects with 2,665 MW capacities have been installed in the country for feeding power to the grid. Bagasse cogeneration projects in sugar mills have capacity aggregating to 1,666 MW. A target of 10,000 MW has set for biomass energy till 2022.

The current availability of biomass in India is estimated at about 500 million metric tons per year. Studies sponsored by the Ministry have estimated surplus biomass availability at about 120 – 150 million metric tons per annum covering agricultural and forestry residues corresponding to a potential of about **18,000 MW**. This apart, about 7000 MW additional power could be generated through bagasse based cogeneration in the country's 550 Sugar mills, if these sugar mills were to adopt technically and economically optimal levels of cogeneration for extracting power from the bagasse produced by them

Wave energy

Wave power is the transport of **energy** by wind **waves**, and the capture of that **energy** to do useful work – for example, electricity generation, water desalination, or the pumping of water (into reservoirs). A generator converts this **mechanical** energy into useful **electricity**. The point absorber consists of a series of long unit, floating on the surface of the water following the movements of the wave. It is this movement that is harnessed and converted to **electricity** in the point absorber. Wave energy is indirectly derived from solar energy and is available at the ocean surface – because of the interaction of the wind with water surface. Wave energy can be generated directly from surface waves or from pressure variations below the surface. Wave energy converters are devices, which can capture wave power for generating electricity and extract useful work like water desalination or pumping of water. India has a coastline of 7,500 km with an estimated wave energy potential of about 40,000 MW.

Tidal energy

Tidal power, also called **tidal energy**, is a form of hydropower that converts the **energy** of **tides** into useful forms of **power** – mainly **electricity**. Although not yet widely used, **tidal power** has potential for future **electricity** generation. **Tides** are more predictable than wind **energy** and solar **power**. Tidal stream generators are very similar to wind turbines except their below the water surface instead of above or on land. The turbine and generator **converts** the movement of water coming from change in tide, the **kinetic** energy, into **electricity**

India boasts of 7,500 kilometers long coastline, being one of the 20 places worldwide where the height of the high tide is over five meters higher than the low tide to capture the tidal power potential. But there are no tidal energy-based power plants in India yet.

India has been looking at generating electricity via tidal power since the 1980s. There were project reports prepared for harnessing this energy from the Panchapada River in Odisha and the Andaman & Nicobar Islands.

The Ministry of New and Renewable Energy made an assessment of the potential of tidal energy in India, it is estimated that the country can produce 7000 MW of power in the Gulf of Khambhat in Gujarat, 1200 MW of power in the Gulf of Kutch in Gujarat and about 100 MW of power in the Gangetic delta of Sunderbans in West Bengal.

As on date it was the Durgaduani Creek, 3.75 MW power plants which caught national attention, was conceived in 1997. In April 2013, it was announced that the project was going to be abandoned due to project cost escalations, despite the Ministry of Non-Conventional and Renewable Energy providing 90 percent of the project costs.

In 2011, there was an announcement that a tidal power plant was under consideration in the Gulf of Kutch in Gujarat. With an initial capacity of 50 MW, it was to be expanded to 200 MW eventually. In 2016, there was news that the Government would tie up with an Israeli firm to set up tidal power plants in Goa.

India has a potential of 8,000 MW of tidal energy as per the estimates. Despite the huge potential, there is no progress in extracting tidal energy. Agreement is signed to implement India's first 3.75 MW mini-tidal power project in West Bengal.

Ocean Thermal Energy Conversion (OTEC)

Ocean thermal energy conversion uses the temperature difference between cooler deep and warmer shallow or surface seawaters to run a ***heat*** engine and produce electricity. It is base load electricity generation system. ***OTEC*** is one of the continuously available renewable ***energy*** resources. Maiden Ocean Thermal Energy Conversion (OTEC) project of India is coming up in Kavaratti, capital of the Lakshadweep archipelago, off the south-western coast after almost three and a half decades of initial plans.

In 2002, **India** tested a 1 MW floating **OTEC** pilot plant near Tamil Nadu. The plant was ultimately unsuccessful due to a failure of the deep sea cold water pipe. The closed cycle and open cycle OTEC technologies are commonly used to extract thermal energy and convert it to electric power. The total OTEC potential around India is estimated as 180,000 MW considering 40% of gross power for parasitic losses.

Geothermal energy

Geothermal energy is one of the potential alternative sources of energy which has been successfully catering to both industrial and domestic energy requirements in many parts of the world over the last few decades. It is interesting to mention here that the amount of heat within 10,000 meters of earth's surface is 50,000 times more energy than all the oil and natural gas resources in the world. The steam and hot water at high temperature and pressure come naturally to the surface of the earth at some places that can be utilised for electricity generation, residential and industrial heating, greenhouses and other local uses.

India has reasonably good potential for geothermal; the potential geothermal provinces can produce 10,600 MW of power (but experts are confident only to the extent of 100 MW). But yet geothermal power projects has not been exploited at all, owing to a variety of reasons, the chief being the availability of plentiful coal at cheap costs. However, with increasing environmental problems with coal based projects, India will need to start depending on clean and eco-friendly energy sources in future; one of which could be geothermal. Union Ministry of New and Renewable Energy (MNRE) recently drafted a national policy, which intends to exploit the sector by generating 1,000 MW in phase-one by 2022. The Indian government's ministry of new and renewable energy (MNRE) on 6 June, 2017, proposes to harness 10,000 MW (10 GW) of geothermal energy by 2030 through active international collaboration with countries such as the US, Philippines, Mexico and New Zealand..

Conclusion

The utility electricity Sector in India had an installed capacity of 305162 MW as on 31/03/2016. Renewable power plants constituted 15% of the total capacity. Out of renewable power generation of 45924 MW, wind is contributed 58% of electric energy and solar is contributed 15% of energy as on 31/03/2016. Renewable power generation has increased to the capacity of approximately 57,700 MW as on 31/03/2017 indicates the enhancement of generation of renewable energy by25 % compare to earlier year. Normally, non renewable energy sources are generating electricity in centralized manner and for utilization of this energy a huge distribution network through transmission line is required. During transmission a reasonable amount approximately in some cases more than 30% wastages of energy is taking place. In case of using of renewable sources as generation of electricity will enhance the encouragement of on-site generation (OSG) or decentralized energy generation which may reduce the transmission losses and indirectly enhance the generation through saving mode. Distributed solar energy can be located on roof top or ground mounted and is typically connected to the local utility distribution grid. In similar manner wind power, mini hydel power, bio mass energy generation must be encouraged to install in different decentralized suitable location to enhance the generation and utilization of renewable energy in India. It is estimated that by 2030 electricity is required is more than 900 GW and as per estimated potential of availability of energy from wind 102 GW and from solar more than 700 GW, there is no other alternative, but it is to be focused to installed solar as well as wind power system in India at suitable location to reduce the dependence of non renewable sources and at the same time reduce the generation of GHG emissions.

References:

1. GENI (Global Energy Network Institute)—Report.
2. Renewable energy in India: Potential, Growth and Policies-by Envecologic, June, 27, 2017.
3. Geo-thermal energy and its potential in India-by Oum Prakash Sharma et.al. Indian science Journal.
4. Ministry of New and Renewable Energy—Report.
5. The potential of renewable energy sources in the energy sector in India—Lekha Chandran.
6. EAI—Report.
7. GWEC Report.
8. Economic Times, India.
9. Market Express News.

India's Energy Transition—Pathways for Low-carbon Economy

Sutirtha Bhattacharyya
Mgr. (PS), STPS, WBPDCL

Abstract

The transition to a low carbon economy heralds an economic and social transformation that is exciting as well as challenging. The challenges that face India include: enhancing economic opportunities and living standards for a growing population and addressing the environmental threats. In this backdrop, if India is to realize its development goals. the path towards a low-carbon economy is inevitable. Approaching a low-carbon economy is of critical importance as the country evolves its economic development model, adjusts its economic structure, enhances its technological innovation capabilities and strengthens the sustainability of its economy. Using a "bottom up" policy framework for low-carbon growth based on national preferences, possibilities and policies, the present study develops a model with two scenarios. One is business-as-usual reference case (BAU) and the other is low-carbon (LC) scenario. We discuss the financing mechanisms and key policy issues. The low-carbon scenario is characterized by increased use of renewables through solar, wind, geothermal, biomass and hydro, which will reduce fossil fuel demand. Also, use of efficient and clean end-use devices in all the sectors will multiply savings. The analysis shows that economy-wide reductions of the order of 30–35% appear to be technically feasible at reasonable costs, relative to the baseline scenario.

1.INTRODUCTION

Energy is an essential ingredient for existence and development. Energy per se is not a need, but the services it provides like cooked food, lighted rooms, and fueled vehicles are. Wider and greater access to energy services is critical in achieving the Millennium Development Goals (MDGs) and thereby helps sustainable human development (World Bank, 2005). Societies with low per-capita energy use tend to have poor human development indicators low life expectancy, high infant mortality, and low literacy (Reddy and Nathan 2010). India, like other developing economies, is in a transition. It occupies 134th position out of 182 countries in Human Development Index (HDI) tally (UNDP, 2012). Nearly 0.4 billion people in India (45.1% rural and 7.8% urban households) do not have access to electricity (IEA, 2012; NSSO, 2011). Similarly, 90% of rural and 33% of urban households do not use clean cooking fuels. Energy services need to be delivered to the deprived so that adequate living conditions in terms of food, water, shelter, health care, education, and employment can be attained (Reddy, 2014). India also faces important challenges in energy use from environment point of view. As per International Energy Agency (IEA) estimates, the world energy-induced CO_2 emissions will increase by 57.4% during 2005–30, and India will account for 14.2% of those emissions (IEA, 2012). However, India's share in incremental world energy demand during the same period will be about 6%. The higher share of pollution can be attributed to two factors—India's heavy reliance on coal, which is of low quality with high ash content (low calorific value); and low share of zero-carbon fuels, which is only 1% in total primary energy demand. Additionally, biofuels, which meet 72% of domestic energy and 90% of all rural energy needs (TERI, 2012), contribute to climate change through black carbon emissions. Like other developing countries, the major dilemma India faces today is on the prioritization of energy goals which need to follow the path of low-carbon economy with efficient management of energy carriers and promotion of renewable technologies. A radical transformation of the energy sector is required to move to a low-carbon economy. This requires a shift to energy efficient and low-carbon technologies that not only displace inefficient devices, but also meet the rapid growth in electricity demand, while maintaining affordable and reliable service to consumers. To achieve this goal, radical changes are required at the institution level. In this perspective, this study bears importance as it takes into account the major energy sources, considers the key variables which influence the energy demand and develops a low-carbon scenario targeting high growth, efficient technology and low-carbon, and compares the results with business as usual case with a focus on energy infrastructure.

2.INDIA'S ENERGY DEMAND OUTLOOK

The demand for energy increases with increase in population base, and change in livelihood and lifestyle needs. In India, the energy demand has increased over six fold over the last five decades, whereas the population has increased by 2.7 times. Table 1 provides the energy demand met by different energy sources (Planning Commission, 2012). While total energy demand registered an average annual growth rate of 3.67% between 1990–91 and 2011–12, the commercial energy demand grew at the rate of 4.93% indicating of a declining growth rate for noncommercial energy sources. The share of oil has remained around one-third of the commercial fuel since 1970. The share of natural gas has increased from 1% in 1970–1 to 8.8% in 2011–12 while that of other renewable sources like solar, wind, small hydro, hydrogen, geothermal forms is below 1% of the total primary energy demand.

3.FUTURE ENERGY SCENARIOS—THE KEY CONSIDERATIONS

In the twenty-first century India faces twin challenges: expanding opportunities for a growing population and addressing environmental concerns. It is about fostering growth and development while ensuring that natural assets continue to provide resources and environmental services on which our wellbeing relies. It is also about enhancing investment and green innovation which will underpin sustained growth and give rise to new economic opportunities and accelerate the transition towards a low-carbon economy (Moe, 2012).

3.1 Macroeconomic and demographic factors

3.1.1 Economic growth

The causality between energy and Gross Domestic Product (GDP) has been established in various cross-country studies. In the Indian context, Sahu (2008) has shown positive relationship between energy and GDP. India's average annual GDP growth rate was about 3% in the 1970s, which increased to 5.6–5.7% in the 1980s and 1990s (RBI, 2009). In the current decade (2001–10), it has accelerated to about 9% between 2005 and 2011 (PMEAC, 2012)..

3.1.2 Population

Increase in population leads to increase in energy consumption simply because with more people there would be more basic energy needs like cooking, lighting and transportation.

The low-carbon economy is characterised by activities which emit low levels of carbon dioxide into the atmosphere. To achieve this, we have to switch from fossil fuels to renewables and increase the efficiency of devices. New fuel-efficient engines, bio fuels in transport sector and energy-efficient devices in household sector are examples of technologies, processes and services which meet this need.

India's population is expected to grow at an average annual growth rate of 1.1% during 2010–30 (Census of India, 2011). In this study it is considered to be 0.1% less because of assumptions of relatively higher GDP growth rate and urbanization would lead to higher household income. Literature shows that income affects fertility negatively (Becker and Lewis, 1974; Jones et al., 2008).

3.1.2 Urbanization

India has a large urban–rural divide in access to modern energy services. In rural areas, 84% of households rely on biomass for cooking and only 8.6% use LPG, whereas the corresponding figures for urban areas are 23% and 57%. Similarly, more than 92% of the urban households are electrified, whereas nearly 44% of rural households depend on kerosene for lighting (NSSO, 2011). The UN (2010) has estimated India's average annual urbanization growth rate at 2.6% between 2010 and 2030. However, we assume it to be 10% more than the UN estimates by 2030. Increase in urbanization improves energy infrastructure and access to modern energy services as it is generally less costly to supply urban communities.

3.2 Supply-side factors

3.2.1 Energy availability and fuel shift

Both the availability and quality of a particular fuel influence its demand. India's coal, though readily available, is of a poorer quality in relation to internationally traded coal. If abundance and indigenous production favour coal among fossil fuels, its high ash content and CO_2 emissions prove to be its disadvantages. Efficiency can be improved with coal washing and blending of indigenous coal with better quality imported coal. In both baseline and LC scenarios the share of imported coal is expected to rise..

3.2.2 Power Plant efficiency

One of the most important concerns under energy infrastructure is the efficiency of plants which transforms natural resources to energy. The thermal efficiency of coal-fired power plants in India is 27%, whereas the same in OECD countries is 37%. This study assumes that the efficiency gap between India and OECD countries remains the same in the baseline, whereas it reduces to half in the LC scenario. This implies that during 2010–30, the plant efficiency increases from 27% to 32% and 37% under baseline and LC, respectively. Higher efficiency under LC is achieved by 2020 through plant modernization and development of integrated gasification combined-cycle (IGCC) and supercritical plant technology.

3.2.3 Control on T&D losses

The energy loss during transmission and distribution is like carrying water in a leaking pot, which makes the vessel half empty by the time it reaches its destination. India's high T&D

losses can be attributed to high voltage network losses, defective or absence of meters, and theft. T&D loss for developed countries is 7−8%. Considering remote rural areas and system configuration, a reasonable and permissible T&D loss for India can be 10−15% (Kumar and Chandra, 2008). In the present model, the T&D loss is assumed to decrease to 23% and 18% by 2030 in the baseline and LC scenarios, respectively.

3.3 Demand-side factors

3.3.1 Vehicle stock and modal shift in transportation

A transportation modal shift from private to public transport system is assumed under LC scenario as the government is proposing to construct rapid transit bus system and urban rail networks. However, personal vehicles will also increase due to economic growth and income expansion making them affordable to large sections of the population (Reddy and Balachandra, 2012). Owing to increased fuel efficiency, under LC, vehicle stock will be higher compared to the baseline.

3.3.2 Energy intensity in Industry

Indian industrial sector has progressed in efficiency over the last two decades, particularly in case of iron and steel, and cement industries. However, there is further scope for improvement since a significant portion of Indian industrial output is derived from small-scale, often rural-based enterprises, fuelled by inefficient boilers, motors, and equipment (Reddy and Ray 2012). LC scenario considers mandatory auditing for energy-intensive industries noted in the Energy Conservation Act 2001, which would lead to a 10% increase in efficiency over baseline.

3.3.3 Household Appliance stock and efficiency

Appliance stock influences electricity demand in households. With increase in disposable income, households' appliance stock will increase, which explains the more than 90%

variation in the residential electricity consumption (Reddy, 1995). Under LC, there would be increase in appliance efficiency. Compact fluorescent lamps (CFLs) are examples of appliances where technological advances have resulted in improvement in energy efficiency by a factor of five without compromising lighting levels. Similarly, improvements in the efficiency of fuelwood stoves and a shift from biomass fuels to gaseous fuels will further reduce household energy use significantly.

4.THE FORECASTING MODEL

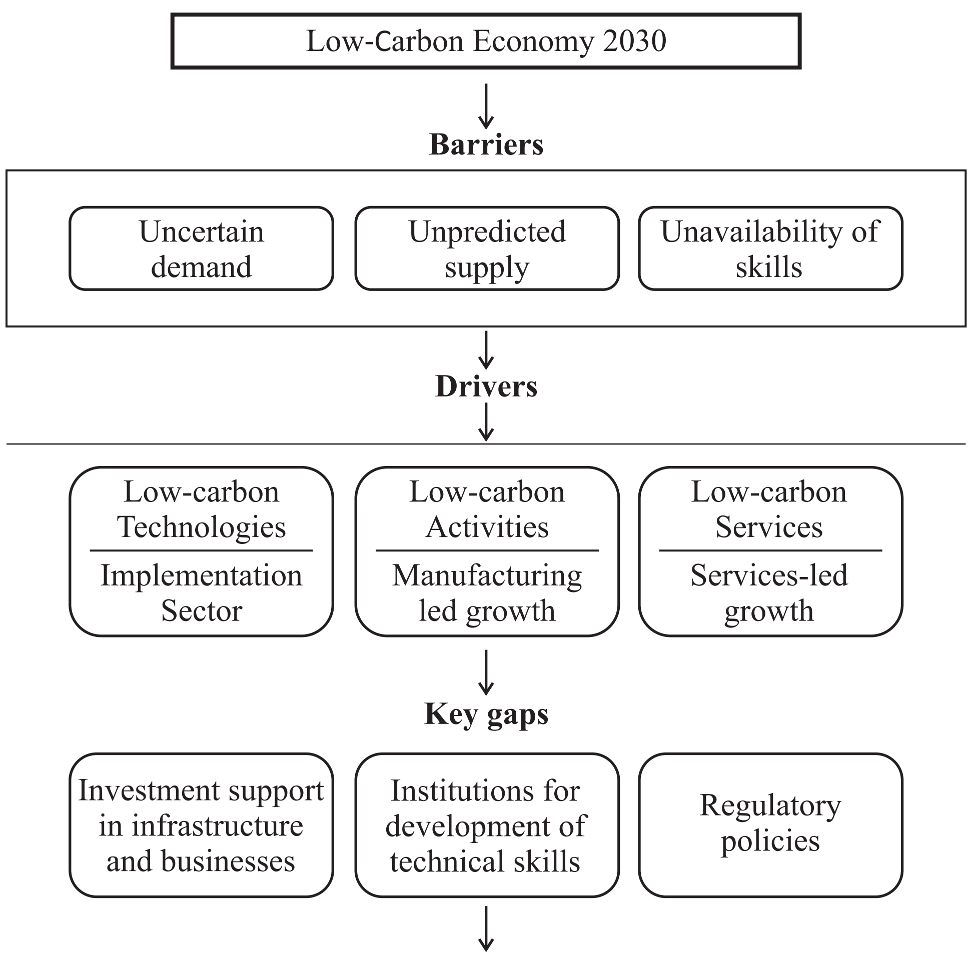
The model developed in this paper is an integrated energy–engineering–environmental– economic system model that is a variant of MARKAL and other such models (Reddy and Balachandra, 2003). Unlike other economic models that have been used previously, this is a bottom-up approach which covers all sectors of the energy economy. While at present there are a couple of national-level models used in government energy forecasting and analysis, there is not a single model that is specific to India. In fact, there are no publicly available bottom-up energy–engineering–environmental–economic models that cover all sectors a country's energy system. As India is striving towards carbon emission reduction, there is a strong need for this kind of transparent, flexible, and accessible model to help form informed policy decisions.

The present model has been developed for forecasting the demand of different energy carriers. The growth rate of each carrier can be expressed by key demographic, macroeconomic, supply, and demand factors as follows[2],

$$d_i = f(g, p, u, s_i, e_i, t_i, i_i, v_i, m_i, n_i, o_i) \quad (1)$$

where, d_i = Demand growth rate for energy carrier i (%), g = GDP growth rate (%), p = Population growth rate (%), u = Rate of urbanization (%), s_i = Rate of change in demand for energy carrier i due to fuel shift (%), e_i = Rate of change in energy efficiency during generation for energy carrier i (%), t_i = Rate of change in T&D efficiency of energy carrier i (%), i_i = Rate of change in energy efficiency of industry using energy carrier i (%), v_i = Rate of change in vehicle stock using energy carrier i (%), m_i = Rate of change in demand of energy carrier i due to mode shift (%), n_i = Rate of change in appliance stock using energy carrier i (%), o_i = Rate of change in efficiency of appliances using energy carrier i (%). The formulation of transition pathways follows an approach based on various elements which include: (i) characteristics of existing energy regime; (ii) technologies, activities and services; and (3) specific gaps at various levels. The relation between these elements is illustrated in Figure 1.

5.RESULTS—ENERGY DEMAND FOR LC VIS-A-VIS BASELINE



Adopted from Charles Levy, 2010

Figure 1: Low-carbon economy—Bottom-up approach

Table 2: Energy demand and CO_2 emission under baseline and LC scenarios

In the low-carbon scenario, the share of fossil fuels will decline to less than three-fourths by 2030. Among the fossil fuels, coal will lose its share by about six percentage points. Oil and gas will decline from 4.9% to 3.7% and 6.8% to 5.0%, respectively. Nuclear and other renewables will increase their share in the total energy demand registering an average annual growth rate of 11.7% and 13.5%, respectively. The share of hydro will not differ much from the baseline

There is a reduction in energy-induced CO_2 emission in LC scenario when compared to the baseline. CO_2 emission in 2030 is estimated to be 2456 Mt, i.e., 29% less than the baseline. The average annual reduction of CO_2 emission turns out to be 403 Mt during the study period.

Various infrastructural needs for generating electricity under LC include (Imodernization of power plants, (ii) efficient power grid of long-distance transmission lines and local distribution lines, (iii) power development of units based on renewable sources, and efficiency improvements in the household and industrial sectors.

6. A POLICY FRAMEWORK FOR LOW CARBON ECONOMY

The Indian government has taken several policy measures with targeted financial provisions to boost low-carbon technology diffusion. However, investors are likely to focus on areas where there are clear and immediate paybacks despite the probability of higher returns over time. This is because of two reasons. The first is the unclear policies and policy frame-work which are still being developed. The second is the heavy focus on economic growth, which depends on the critical role of fossil fuels to power it. That is, access to energy and energy security is likely to be dominant considerations for policymakers (Venugopal and Srivastava, 2013). This has implications for the level of support that will be provided to low-carbon technologies.

6.1 Prioritizing supply efficiency

To reduce the un-predictability of supply, improved supply efficiency is essential since it eases the supply constraints by producing more output from the same input. At the same time, it reduces pollution by releasing less CO_2 for the same energy use. In the present study, two supply-side efficiency factors are identified to be critical for LC scenario—generation and T&D—both requiring technology improvements. Efficiency needs to be targeted as a policy-strategy. Due to shortage of funds, T&D loss investment gets low priority than new generation. Hence, it must be emphasized that new generation is incremental, whereas check on T&D loss can be universal gain, which can lessen generation need. T&D loss coupled with absence of accounting in certain cases has been identified as the critical cause of financial losses for the distribution companies and State Electricity Boards (SEBs) (Kumar and Chandra, 2008).

6.2 Commercialization of renewable energy technologies

The energy efficient and renewable energy technologies will take two to three decades for diffusion to dominate the market. To diffuse quickly, the new (low-carbon) technologies need a bundle of desirable attributes which include: (i)*Technological Dynamism:* continued innovation, so costs fall/quality rises, (ii) *Innovational Complementarities:* users improve own technologies and find new uses. Also, technology developers should ensure that the technology (i) should be competitively priced, and (ii) should have appropriate carbon price. However, for the technology to successfully penetrate and change the consumer behaviour appropriately, there is an urgent need for policy interventions.

India is considered as one of the leaders in renewable energy field which includes biogas, solar, wind, small hydro power and other emerging technologies. Solar water heating, is virtually free from government subsidies and is considered the most successful renewable energy technologies (RET). Wind energy has achieved the highest penetration into the market among all RETs. The growth rate in capacity is 35% in the last three years, and most of it has come through commercialized projects and private investment. India has a strong technology and manufacturing base to produce wind turbines and blades indigenously and they are exported to both developed and developing countries. Small hydro projects are the next RET, which are attracting private sector participation; and most capacity addition is now being achieved through private investment. The state acts as a facilitator in terms of survey on project sites, renovation and modernization of old stations and development/up-gradation of water mills, customs duty and tax concessions.

6.3 LC technologies—Skill development

Despite high unemployment rate, Indian companies are finding it difficult to source people with the required skills that a modern manufacturer needs. Much needs to be done to help companies get the skilled workers they need. Targeted collaboration between the public and private sectors is needed. In LC technology industry, the direct and indirect employment is in photovoltaic equipment production and manufacturing, raw material industries and other solar-power generation industries. We propose two ways in which businesses and government can collaborate to close this skills gap. The first is the collaboration between government authorities and business houses to develop industry-endorsed training programs that give graduates nationally recognized technological skills and provides skilled employees with a diploma certificate.

6.4 Demand side efficiency—Activities and Services

Energy efficiency in the residential involves the replacement of inefficient technologies with efficient ones and fuel switching from non-renewable to renewable technologies. In the residential sector, fuel shifts—from biomass fuels to gasous fuels (biogas and LPG), and technology shifts—replacement of existing inefficient devices with efficient ones (for cooking, lighting, water heating, etc.). With low-capital costs and high returns, efficiency measures hold out the promise of relatively low cost abatement that works directly to delink carbon from growth, the essence of a low-carbon economy. The efficiencies can be improved to as high as30 %, from the existing 10%, through improvements to stoves at negligible costs. To realise the potential for biogas, we need to build a national gas grid to feed bio-methane into the grid. Similarly, there should be shift from inefficient IB to efficient CFL. Since 20% of the electricity use is from the household sector and 40% of household electricity use is for lighting, the shift will lead to a full transformation of the market.

6.5 Infrastructure security

Security to energy infrastructure is important since it is vulnerable to physical disruptions, which could come from natural events like earthquakes, or from accidents. Any disruption in the infrastructure can have significant consequences for other sectors as it interconnects them through complex and inter-dependent network. Consequently, security must form an integral part of energy infrastructure policy.

6.6 Required Mechanisms

6.6.1 Financial Mechanism

The greatest challenge the country faces in moving to a low-carbon economy is financing the upfront costs of technology investments and designing supportive policies and programs to overcome the barriers to regulatory, institutional, and market development. The typical characteristics of any energy infrastructure program are higher initial expenses which result in lower energy bills in the future. Higher spending by consumer inhibits the full realization potential of the infrastructure. For example, in India's rural electrification program, the whole effort to make electricity available to rural households goes in vain as the final connection to the household remains unaffordable to the villagers. This makes households to rely on kerosene for lighting, which is inefficient and causes indoor air pollution. It also defeats the purpose of kerosene subsidization. Models based on entrepreneurs, who act as middle layer between government and consumers, can help overcome this bottleneck. For some interventions, in particular, in energy efficiency, the initial investments are offset by savings.

6.6.2 Institutional mechanism

It is important to develop new institutions, enhance the capacity of the existing ones, and clubbing all to develop and implement LC policies and integrate them into existing processes rather than creating stand-alone policy agencies. The policies include macro and structural economic, energy and environmental, transport and infrastructure, and innovation. The political responsibilities for these policies should be divided between the Ministries of Energy and Finance, and a number of line ministries including Ministries of Environment and Forests.

6.6.3 Market risks

Low-carbon market risks, including policy, technology, and operational risks which range from unexpected policy changes to technology failures can significantly affect low-carbon markets. If the market is new, then, public financing instruments like first-loss equity, debt investments and concessional loans can encourage investment. In mature markets like solar, wind, and energy efficiency, flexible loans, partial risk and credit guarantees, and risk sharing facilities will boost the investor confidence. Given the varied investment conditions in India what is required is a unique combination of finance and policy support to scale-up private sector investment.

7.CONCLUSIONS

Under the climate regime India's energy sector faces a difficult challenge. On one hand, the country needs to expand its energy base to sustain growth, make energy reach the deprived, while, on the other hand, energy course needs to follow an efficient and low-carbon path. In this paper, we tried to map these twin objectives through a sustainable development strategy. We have forecast future demand for different energy carriers under two scenarios: baseline and low carbon future (LC). The important factors influencing energy demand are GDP, population, urbanization, resource availability, and diversification of energy supply, efficiencies in generation, transmission and utilization, growth of vehicles and appliances, and modal shift in transportation. Through a mathematical model, the growth rates for different energy carriers are estimated and the demand projections are made.

Making effective and efficient investments by the government in the LC economy is a complex one. It requires weighing diverse criteria against one another, from emission reduction potential to macroeconomic impacts to social considerations. Understanding of issues involved, risk factors associated with heavy public expenditure, and the evaluation criteria that provide critical tradeoffs will be crucial in making public policy and investment decisions, and successfully building a low-carbon economy.

References

Anon, 2011, Census of India. 2011, Distribution of households by source of lighting. Government of India, New Delhi.

A review and discussion on roof top Solar Energy System/Devices

Gautam Kr Das
DGM (Mechanical), DCPL, Kolkata

Abstract:

Globally almost 20% of the World's population doesn't have access to electricity. While energy demand is rapidly increasing, driven by economic growth and growing population, the challenge is to provide electricity to all, especially to those living in remote villages - far away from the city/ power generation centers.

Climate change presents humanity with a significant challenge. As a result, low carbon alternatives might offer the greatest commercial opportunities of the current era.

Solar installations have increased phenomenally in the last couple of years. World Solar PV installations have been increased from 3.6 GW in 2005, to 200 GW in 2015.

The Solar installations are rising in the developing countries, increasing the opportunity for investment in green energy sector. Favorable policies are already in place in many countries to maintain the upward trend in Solar energy growth.

The Government of India has set an target of 100 GW solar power by 2022. Significant portion i.e. 40 GW shall be activated from grid-Interactive roof top solar PV Plants. Various schemes have been developed to promote Solar energy installations to individuals. Government of India scaled-up the budget from Rs. 600 Crore during the 12th year plan to Rs 5000 Crore for implementation over a period of five years (upto 2019-20) for grid connected roof top and small Solar Power Plants.

Review and critical analysis of various kinds of roof top solar installations shall be made here in this article.

The types of Solar Energy devices can be used at the roof top have been elaborated below:

1. Solar cells / solar trees can be used on the roof of the building as well as on the walls of the building suitably for generation of electrical energy. If the generated electricity is to be used for in-house consumption, in that case Power conditioning unit and storage batteries are necessary. Else, the roof top solar cells/ small solar power plants (within the range of 1 to 500 KW) can be grid interactive.

Government of India is encouraging for the Grid connected Roof top and small solar power plants for the individual-households also. Central financial assistance (CFA)and achievement linked incentives / awards are also available. The Sector-wise eligibility of CFA varies from 30% to 70%.

The drawback of the Solar cell is its unsteady performance due to dust accumulation on the surface and sharp degradation and de-rating within small span of time. Hence spray water cleaning system shall be provided for regular cleaning of the Solar cells and the replacements are necessary to get the best performance. The Solar cells must withstand rain, hail, heavy wind, load, and cycles of heat and cold for many years. Many crystalline silicon modules manufacturers offer a warranty that guarantees electrical production for 10 years at 90% of rated power output and 25 years at 80%. Potential induced degradation (also called PID) is potential induced performance degradation in crystalline photovoltaic modules, caused by so-called stray currents. These effects may cause power loss of up to 30% .

2. Solar water heater cum boiler can be used as a part of the roof top hot water storage tank for in-house use.The Solar Boiler collects energy from the sun and converts it into hot water. Domestic hot water is the second-highest energy cost/expenditure in the typical household. In fact, for some homes it can be the highest energy expenditure. Solar water heating can now reduce your domestic water heating costs by as much as 65%.

   Modern Solar Boilers are today's state-of-the-art solar water-heating appliances. Designed to pre-heat the domestic water that is supplied to the conventional water heater, it can result in remarkable savings. It's easy to install, and is maintenance free. All parts of the system are tailor-made, built to demanding specifications, employing the latest solar technology for maximum performance. The Solar Boiler is manufactured from readily-available components, ensuring lower costs and reliability. The solar collectors are constructed of aluminum, copper, and tempered glass. The Solar Boiler is environment-friendly. It does not pollute or use valuable non-renewable resources. Even the pump to transport heat from the collectors to the storage tank is powered by the sun. The Solar Boiler is designed for automatic daily and year-round operation. Passive solar water heating system does not require electrical pump to move the water up. Or else a photovoltaic module has to regulate the proper daily operation of the Solar Boiler and the solar loop circulator turns on only when the collectors are hot enough to heat the solar tank.

Conventional energy requirements can be reduced substantially by using the Solar Boiler, and on many days the Solar Boiler will provide ample hot water without the backup (conventional) heater turning on. In most families, the Solar Boiler will provide up to 65% of the water heating requirements. A typical system for a family of four would include two solar collectors (6 square meters), 270 liters of solar water storage and a photovoltaic module to drive the pump. Perhaps currently, no subsidies are available from the Government for this kind of solar hot water boiler.

3. Solar parabolic concentrators can be used on the roof top of series of same height modular buildings for generation of steam. The steam generated from the Solar parabolic concentration can be used for generation of electricity and the exhaust steam can be used for cooking and room heating purposes.

4. Solar distilled water plant can be set-up on the roof top of the building and the bottling plant can be made at the ground floor of the building.Direct solar evaporation technology emits no greenhouse gas emissions, uses no chemicals, no costly membranes are used, no filters are required, no electronics involved, and no ongoing power source is required other than solar radiation. Solar distilled water plant produces safe, high quality potable water from any source including sea-water, ground-water and contaminated or polluted water. It also incorporates Zero Liquid Discharge (ZLD) technology, which converts waste water into drinking water.

Low cost, robust, modular solar water heater panels can be roof mounted. The design enables multiple panels to be connected together to produce larger quantities of distilled water from a single source. The panels can be supplied individually or in bulk. Single panels are ideal for family use, a series of panels will provide for a village or the panels can be set up as a large scale water farm. The design of Distilled water plant enables rainfall to be captured and harvested as well.

Solar insolation increases the temperature of the feed water on the solar collector which enhances the evaporation / condensation processes inside the panel. The condensated water is collected as drinking water which can be bottled after adding necessary minerals. The bottling plant can be installed at the ground floor of the building suitably.

Author :
1.Gautam Kr Das, B-Tech (IIT-Kharagpur), MBA(finance, Marketing & HRD).
118/A A J C Bose Road, Kolkata – 700014, Mb: 9830178272, email: gautamkd@gmail.com

6th National Seminar of EWF at Swabhumi,Kolkata,Dated: 5.11.2017