GHG emission factors, carbon content and heating value of Indian coals

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Introduction

- **The total production of energy from commercial sources in India was 13767.83 peta joules during 2015-16.**

- **Energy production in PJ by commercial sources shows that coal was the major source of energy during 2015-16:**
  - **Coal - 70.25%**
  - **Crude Petroleum - 11.24%**
  - **Natural Gas - 9.02%**
  - **Electricity (Hydro, Nucl., Others) - 5.87%**
  - **Lignite - 3.62%**

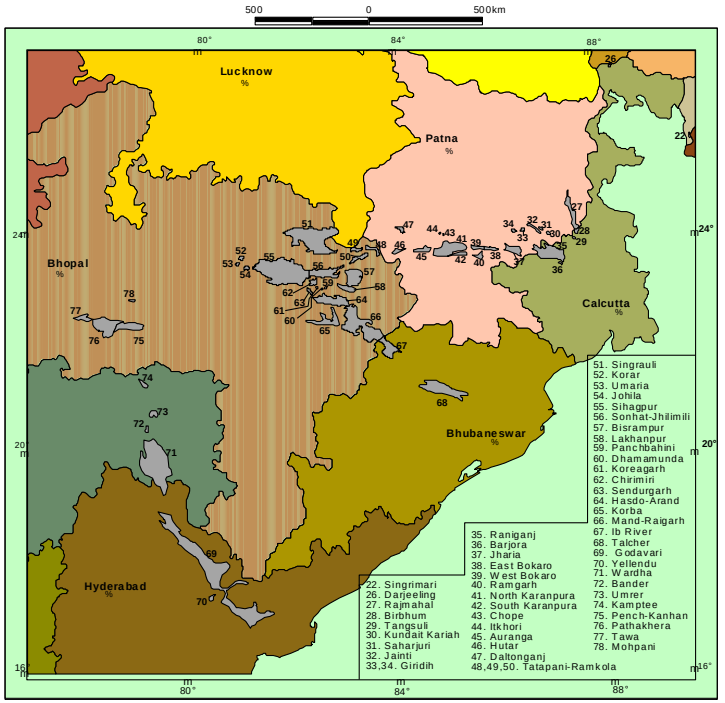
Source: Energy Statistics 2017, Ministry of Statistics and Programme Implementation, Govt. of India

Occurrence of coal in India

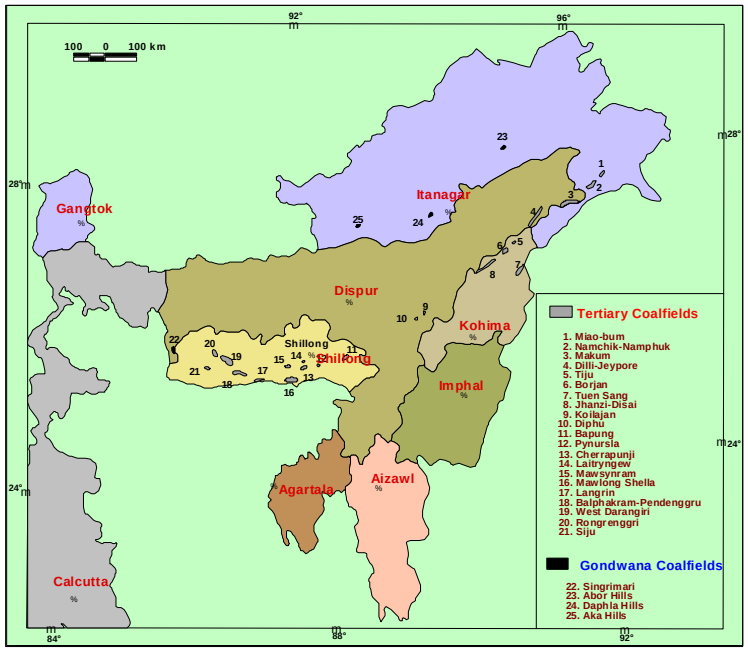
Indian Coal occurs in two stratigraphic horizons

Permian sediments (c. 290Ma) mostly deposited in Intracratonic Gondwana basins.

Gondwana coalfields



Tertiary coalfields



Early Tertiary (c. 60Ma) near-shore peri-cratonic basins and shelves.

Geological Provinces

Gondwana coal

Occurrence	Eastern and central part of Peninsular India
Rank	Bituminous to sub-bituminous
Character	Moderate to High in Ash and Low in Sulphur

Tertiary coal

Occurrence	Northeastern India
Rank	Meta and Ortholignitous
Character	High in Sulphur; Strongly caking to non-caking

Lignite

Occurrence	Western and southern India
Character	High in moisture and volatile matter

Gondwana Coal

Coal bearing strata

RANIGANJ/KAMTHI FORMATION **(Late Permian)–**

ECONOMICALLY EXPLOITABLE IN RANIGANJ, JHARIA

EASTERN PART OF SINGRAULI BASIN AND GODAVARI

BARAKAR FORMATION **(Early Permian)–**

MAJOR STOREHOUSE OF COAL IN ALL THE BASINS

KARHARBARI FORMATION **(Early Permian)–**

RESTRICTED TO FEW COALFIELDS OF EASTERN INDIA

Tertiary Coal

Coal bearing strata

Oligocene sediments

- Tikak Parbat Formation in Upper Assam, Nagaland and Arunachal Pradesh

Eocene sediments

- Tura Sandstone, Lakadong Sandstone in Garo, Khasi and Jaintia hills of Meghalaya
- Sylhet Limestone in Mikir hills of Assam
- Lower Subathu Group in Jammu

Types of Indian Coal

Coking

Prime – Low volatile bituminous coals , Coke type G_7 or better, R_o(mean) = 1.2. Upper Barakar seams in Jharia coalfield.

Medium - Low to high volatile bituminous coals, Coke type F-G_6, R_o(mean) = 1.1-1.4. Lower Barakar & Raniganj seams in Jharia, Barakar seams in Raniganj, Bokaro, parts of Ramgarh, Karanpura, Sohagpur and Pench- Kanhan coalfields

Semi – High volatile, Coke type D-F, R_o(mean) = 0.7. Lower Raniganj seams in Raniganj, Barakar seams in parts of Ramgarh and Sonhat coalfields

Non-coking

Superior – High volatile bituminous B-C coals. Mainly in Raniganj seams of Raniganj coalfield

Inferior – High volatile sub-bituminous coals. All coalfields

High Sulphur **Tertiary coalfields of Northeastern Region**

General Characters of Karharbari Coal

- Low moisture, low ash and low to medium volatile
- Comparatively cleaner than Barakar coals
- Generally non-coking except in parts of Giridih and North Karanpura

General Characters of Barakar Coal

- Moisture < 2% to 6%
- Volatile - <18 to 35%
- Carbon - 85 to 90% (on dmmf basis)
- Ash - 15 to 30% (excluding dirt bands)
- Coking properties (eastern CFs of Damodar Valley basins)
- Coke type - D to G_6 or better

General Characters of Raniganj Coal

- High moisture
- High Volatile
- Coal seams thinner than those of Barakar
- Best developed in Raniganj coalfield

Resources classified as

CATEGORY : **(Based on degree of confidence)**

- *PROVED (>80%)* — **THROUGH DETAILED EXPLORATION**
- *INDICATED (>50 to 80%)* — **THROUGH REGIONAL EXPLORATION**
- *INFERRED (<50 %)*

DEPTH : ***0-300 m, 300-600 m and 600-1200 m***

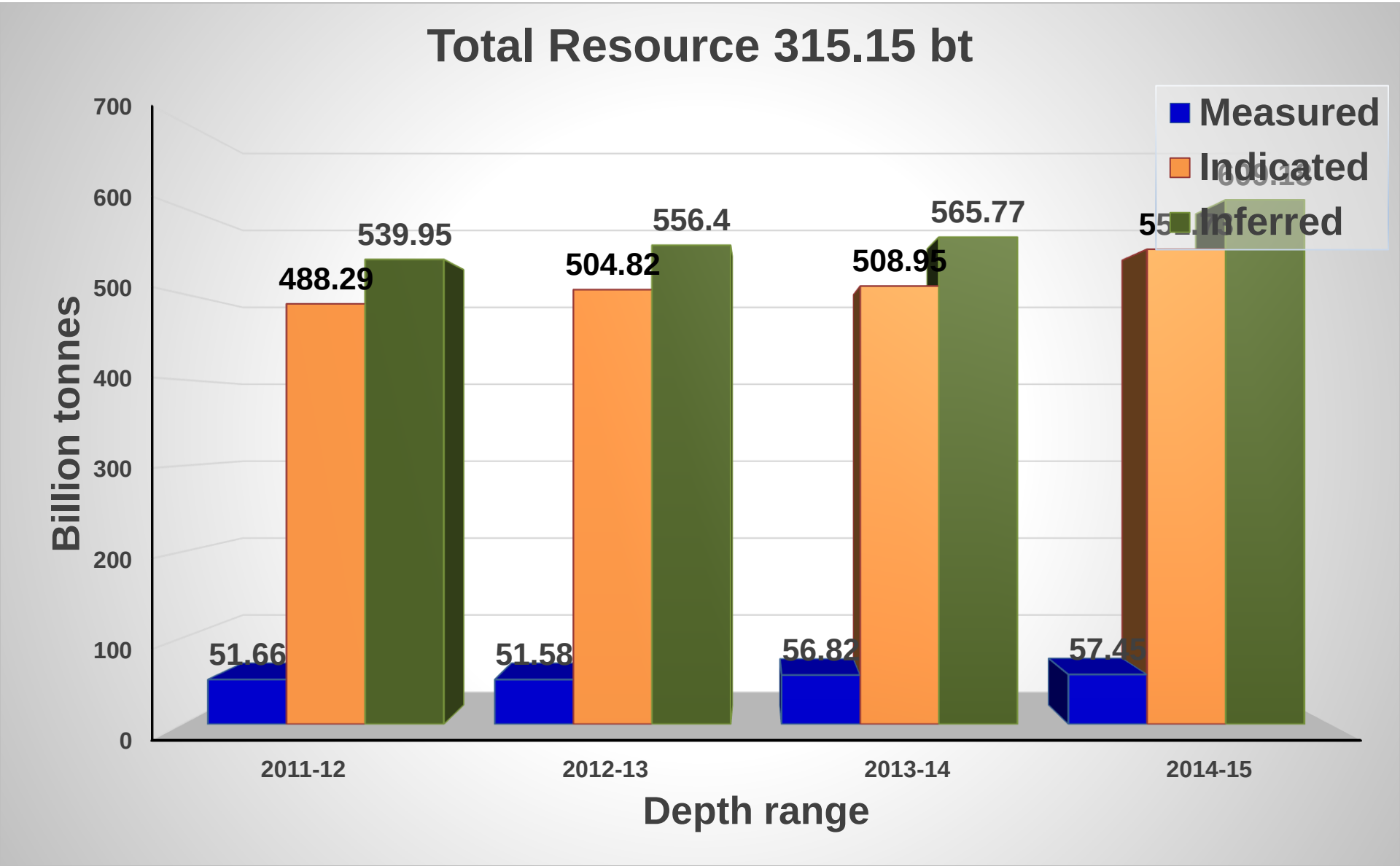
GRADE :

Medium Coking : SG-I, SG-II, W-I, W-II, W-III, W-IV

Semi Coking : Grade-I and grade-II

Non Coking : Superior (Gr.A – C) and Power grade (Gr.D-G)

Depth-wise and Category-wise Resource of Indian coal (As on 1.4.2017)



Prevalent Quality Classification System

Coking coal

Grade	Ash	Sp.Gr
Steel Grade -I	< 15%	1.42
Steel Grade -II	15% - 18%	1.44
Washery Grade - I	18% - 21%	1.46
Washery Grade - II	21% - 24%	1.50
Washery Grade - III	24% - 28%	1.53
Washery Grade – IV	28% - 35%	1.58

Semi-coking & weakly coking coal

Grade	Ash + Moisture	Sp.Gr
Semi-Coking -I	< 19%	1.44
Semi-Coking -II	19% - 24%	1.46

Quality Classification (Contd…)

(Department of Coal, Ministry of Energy, 1979)

Non-coking coal

Grade	Useful Heat Value (k.cal/kg)	Sp.Gr
A	> 6200	1.42
B	5600 - 6200	1.45
C	4940 - 5600	1.50
D	4200 - 4940	1.55
E	3360 - 4200	1.60
F	2400 - 3360	1.68
G	1300 - 2400	1.76

Useful Heat Value = 8900 – 138 (Ash + Moisture)

(At 60% R.H & 40^0C Temperature)

New GCV based classification system of non-coking coal

(Gazette Notification, Ministry of Coal, 30th December 2011)

Old UHV based grading	New GCV based grading	GCV Range (KCal/kg)
A	G1	➢ 7000
	G2	6701 - 7000
	G3	6401 - 6700
B	G4	6101 – 6400
	G5	5801 – 6100
	G6	5501 - 5800
C	G7	5201 - 5500
B	G8	4901 – 5200
	G9	4601 – 4900
E	G10	4301 – 4600
	G11	4001 – 4300
F	G12	3701 – 4000
	G13	3401 – 3700
G	G14	3101 - 3400
	G15	2801 – 3100
Additional Grades	G16	2501 – 2800
	G17	2201 - 2500

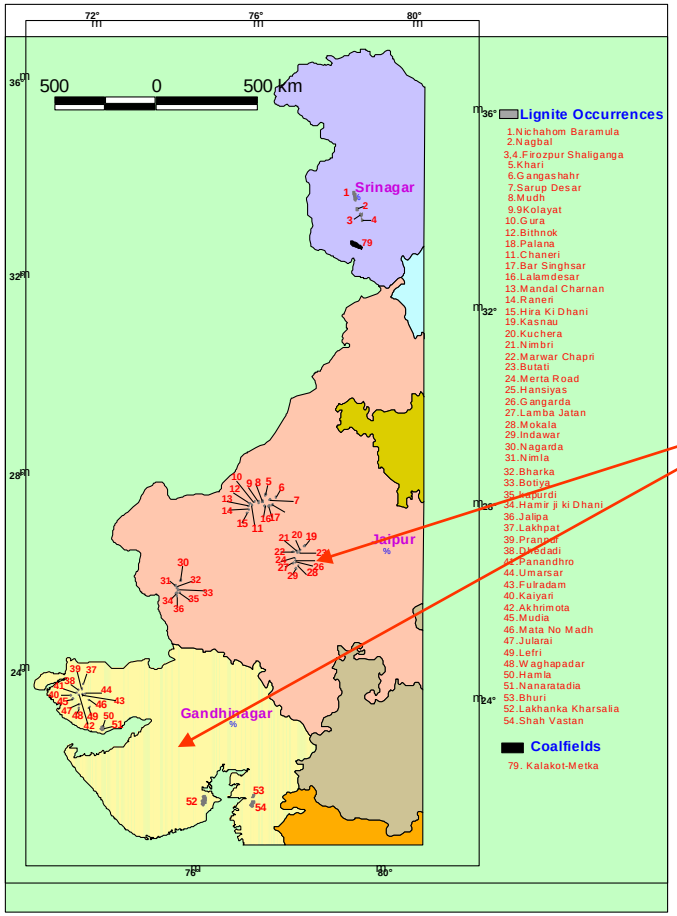
Summarized Table of Coal Resources

As on 1st April 2017

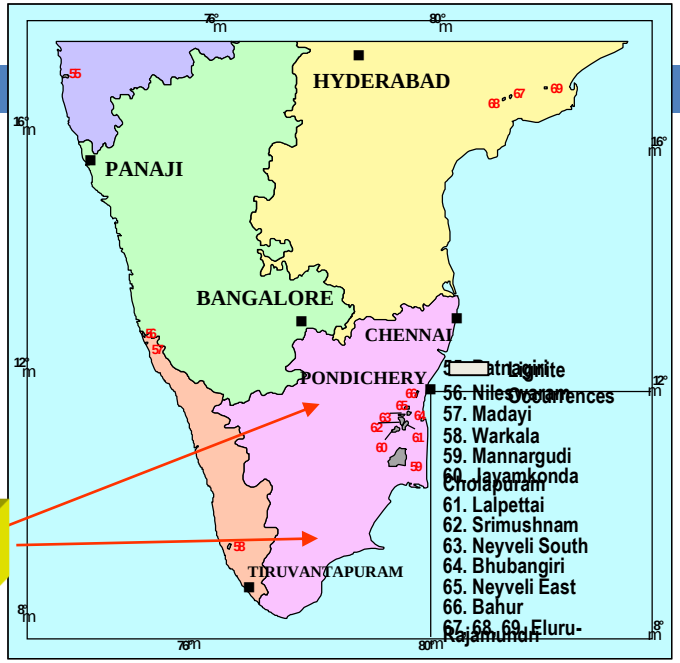
(in billion tonnes)

Depth Range	Coking			Non-Coking			High Sulphur	Grand Total
(m)	Prime	Medium	Semi-Coking	Superior (G1-G6)	Inferior (G7-G17)	Ungraded		
0-300	0.00	11.59	0.47	21.69	137.98	9.03	1.39	182.15
0-600	4.04	4.06	0.00	0.20	5.90	0.00	0.00	14.20
300-600	0.00	6.42	0.76	12.75	58.68	15.88	0.20	94.69
600-1200	1.27	5.44	0.49	2.86	9.15	4.90	0.00	24.11
0-1200	5.31	27.51	1.72	37.50	211.71	29.81	1.59	315.15

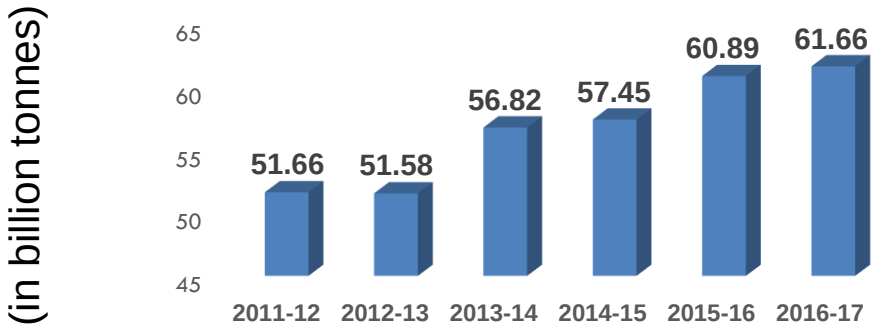
Lignite Resources



Workable deposits

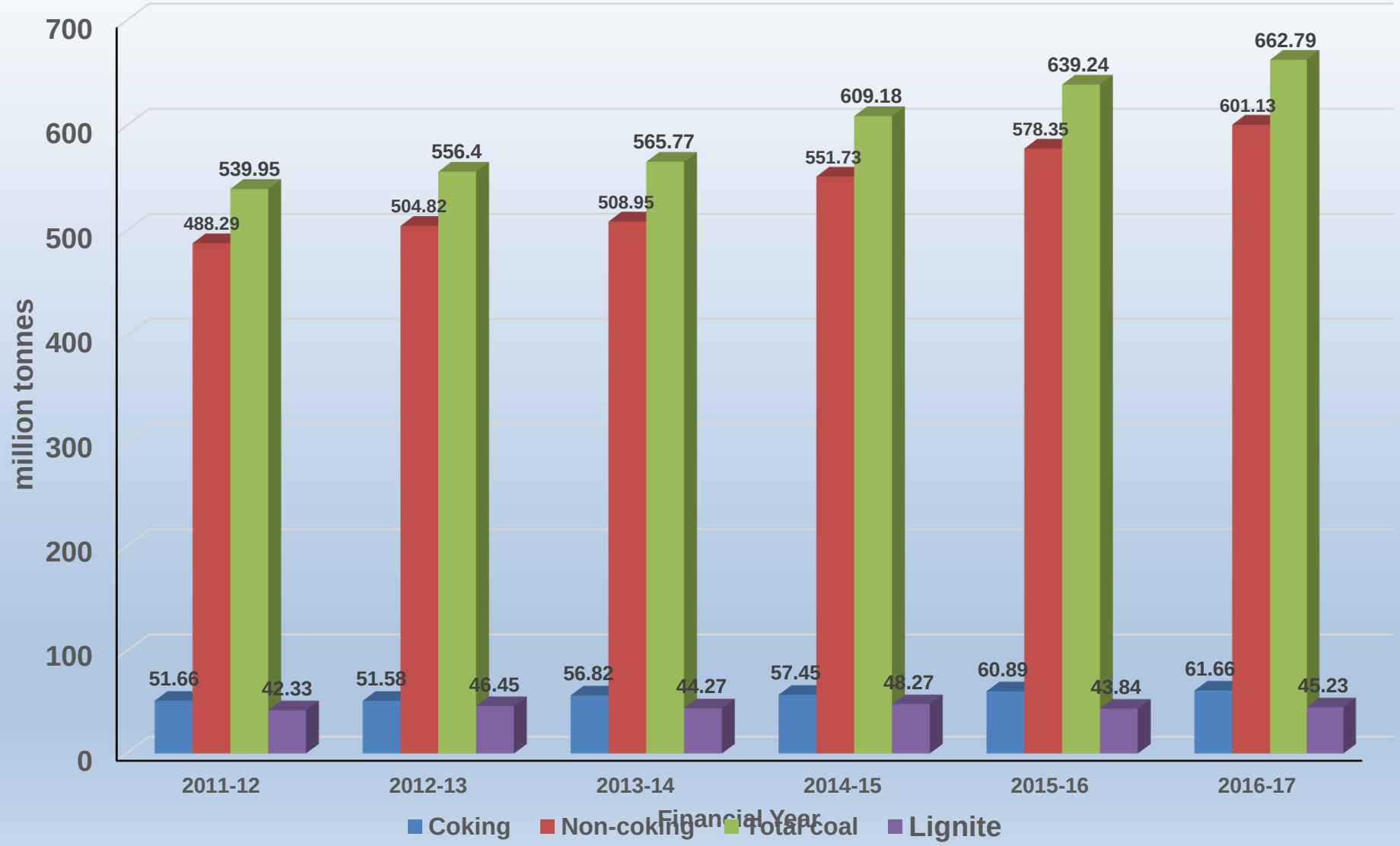


Total Resources - 44.70 bt



Trend of Coal and Lignite Production

(in million tonnes)



Methodology Adopted for NCV, CEF

- **Collection of coal/lignite characteristic data from CFRI archive covering the major sources of coal and from M/s NLC India Limited**
- **Identification of outliers**
- **Categorisation of the data into three broad groups - Coking (400) Non coking(3300) and lignite (4400)**
- **Estimation of the NCV/CEF for each grade of different categories of coking and non coking coals. Use of grade wise production data for estimation of NCV and CEF of coking & non coking coals**
- **Compare the estimated figures with the Previous values**

NCV and CEF of Coking Coal

Grade	Mean NCV	Mean CEF	Production (MT) Year		
			1994	2000	2006
Steel Gr. I	28.83	25.39	0.388	0.195	0.127
Steel Gr. II	28.13	25.40	1.267	0.675	0.559
Washery Gr. I	27.09	25.45	2.296	1.035	0.291
Washery Gr. II	26.08	25.49	4.487	3.374	3.171
Washery Gr. III	24.73	25.53	10.491	6.889	6.737
Washery Gr. IV	22.95	25.56	22.770	18.507	20.999
Semi-Cok. Gr.I	26.39	25.71	0.271	0.215	0.182
Estimated	NCV (TJ/kt)		24.18	24.00	23.80
	CEF (tc/TJ)		25.53	25.54	25.55

IPCC Default Values NCV = 19.98; CEF= 25.8

NCV and CEF of Non-Coking Coal

Grade	Mean NCV	Mean CEF	Production (MT) Year		
			1994	2000	2006
A	25.63	25.70	2.974	3.548	4.958
B	23.92	25.81	21.417	20.694	20.815
C	22.37	25.78	46.742	51.728	53.059
D	20.34	26.06	33.853	37.067	42.439
E	18.26	26.28	41.603	62.708	98.079
F	15.87	26.51	63.771	101.824	165.673
G	13.70	26.82	0.358	0.458	7.733
Estimated	NCV (TJ/kt)		19.63	19.08	18.45
	CEF (tc/TJ)		26.13	26.20	26.27

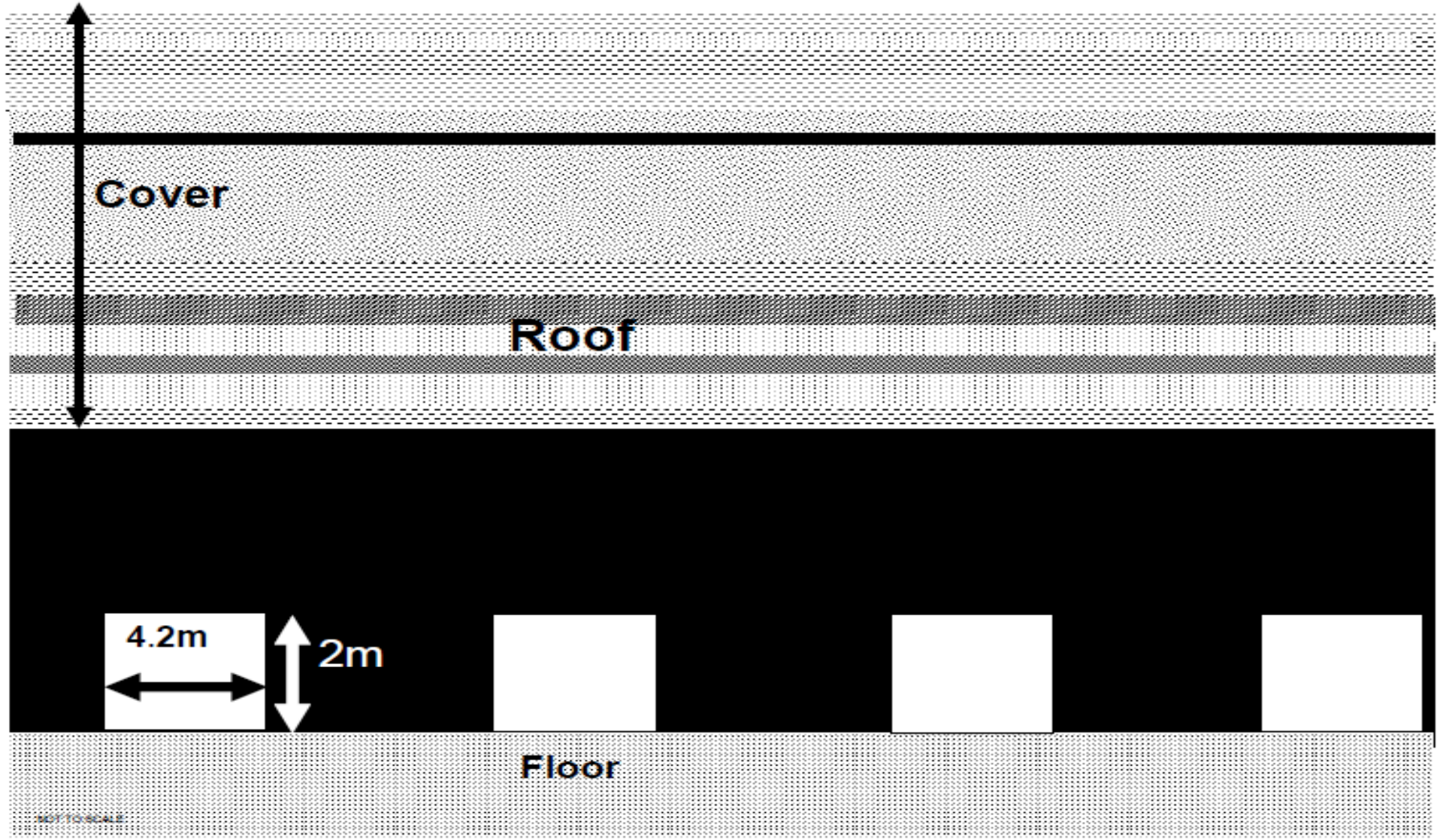
IPCC Default Values NCV = 19.98; CEF= 25.8

NCV and CEF of Lignite

	Moisture 45%	Moisture 50%	Moisture 55%
NCV (TJ/kt)	10.90	9.69	8.50
CEF (tC/TJ)	28.29	28.95	29.80

Fugitive Emission from Coal Mining and Handling Activities

Methane Emission in Underground Mining of Coal



Methane Emission in Surface Mining of Coal

Methane Emission in Handling Activities

Methane Emission Factors

Operation	Methane Emission factor (m^3/tonne)			
	Surface Mining	Underground Mining		
		Degree–I	Degree–II	Degree–III
Mining	1.18	2.91	13.08	23.68
Post Mining (Handling)	0.15	0.98	2.15	3.12

Quality Control and Quality Assessment

- During data analysis for CEF and NCV estimation, integrity of the data was assured through cross checking of experimental GCV's with the values obtained from the elementary data using the formula proposed by B .K. Mazumdar.

- **Uncertainty Assessment:** While estimating the NCV and CEF of the Indian coals the grade wise production data of coking and non-coking coals were utilised. Since there is wide variation in the NCV figures between the grades of each coal type any uncertainty in the production figures will affect the accuracy of the estimated parameter. The CEF value is not affected in a significant way by the production

Conclusions

- **Institutions in India have developed their own national emission factors.**

- **A number of constraints usually experienced need to be addressed strategically by the participating Institutions, Industries and the MoEFCC, GoI.**

- **The following additional measures for success in our endeavour :**
  - ✓ *Pro-active support of and co-ordination among policy makers, regulators, Institutions andother government agencies, etc.*


Thank
You!