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PROCEEDINGS OF THE
EEC-VGB-WORKSHOPS
November 2016

Technical Workshops in Kolkata, Raipur and Hyderabad

# "Implementation of New Environment Norms for Thermal Power Generation – Learnings from German Experiences"


www.vgb.org

## Introduction

The Excellence Enhancement Centre for the Indian Power Sector and VGB PowerTech from Germany organised three regional works on the topic “Implementation of New Environmental Norms for Thermal Power Generation – Learnings from German Experiences” under the auspieces of the Indo-German Energy Forum. The workshops were held in Kolkata, Raipur and Hyderabad on 15, 17 and 19 November 2016.

Delegates from various generating organizations such as NTPC, WBPDCL, Tata Power, TSGENCO, APGENCO, CSPGENCO and DVC participated in the workshops. Representatives of Central Government Departments including CEA as well as representatives of the State of Chhattisgarh were also present. About 250 participants attended the workshops; in each city German experts presented nine technical papers. The workshops were sponsored by:

Sponsor in Kolkata, Raipur and Hyderabad

NTPC

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DVC, HAMON, WBPDCL

Co-sponsor in Kolkata and Hyderabad

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## Facts and figures

The following tables include an overview of the emission limits for existing and new build plants in India and Germany.

### Comparison of emission limits for existing plants

| Emission | Indian emission limits for TPPs installed before 31 Dec 2003 | Indian emission limits for TPPs installed between 31 Dec 2003 and 31 Dec 2016 | European emission limits according IED 2010 >300 MW | Expected European emission limits according BREF* >300 MW |
|---|---|---|---|---|
| PM | 100 mg/Nm³ | 50 mg/Nm³ | 20 mg/Nm³ | 300 – 1000 MW: 2 – 12 mg/Nm³ > 1000 MW: < 2 – 8 mg/Nm³ |
| SOx | < 500 MW: 600 mg/Nm³ > 500 MW: 200 mg/Nm³ | < 500 MW: 600 mg/Nm³ > 500 MW: 200 mg/Nm³ | 200 mg/Nm³ | Pulverised coal: 10 – 130 mg/Nm³ FBC: 20 – 180 mg/Nm³ |
| NOx | 600 mg/Nm³ | 300 mg/Nm³ | 200 mg/Nm³ | FBC, lignite: 85 – 175 Other: 65 – 150 |
| Mercury | > 500 MW: 0.03 mg/Nm³ | 0.03 mg/Nm³ | none | Hard coal: 1 – 4 µg/Nm³ Lignite: 1 – 7 µg/Nm³ |

*Yearly average

### Comparison of emission limits for new build plants

| Emission | Indian emission limits for units to be installed from 1 January, 2017 | German emission limits > 300 MW |
|---|---|---|
| PM | 30 mg/Nm³ | 10 mg/Nm³ |
| SOx | 100 mg/Nm³ | 100 mg/Nm³ + 85% deposition rate |
| NOx | 100 mg/Nm³ | 150 mg/Nm³ (100 mg/Nm³ annual average) |
| Mercury | 0.03 mg/Nm³ | 0.03 mg/Nm³ (0.01 mg/Nm³ annual average) |

## Facts and figures

The next table shows typical coal compositions utilised in Indian and German power plants. The ash content of Indian coal is much higher than the ash content of German lignite and imported hard coal. Compared to German lignite the water and sulfur content of the Indian coal is quite low.

### Overview of typical coal compositions

| Type of coal | Calorific value [kJ/kg] | Ash content [%] | Water content [%] | Sulphur content [%] |
|---|---|---|---|---|
| Indian coal | 11,715 – 20,900 | 25.0 – 50.0 | 10 – 20 | 0.30 – 0.80 |
| German lignite | 7,800 – 11,300 | 2.5 – 20.0 | 40 – 60 | 0.15 – 3.00 |
| Imported hard coal applied in Germany | ~25,000 | 7.0 – 15.0 | 9.0 – 12.0 | < 1.00 |

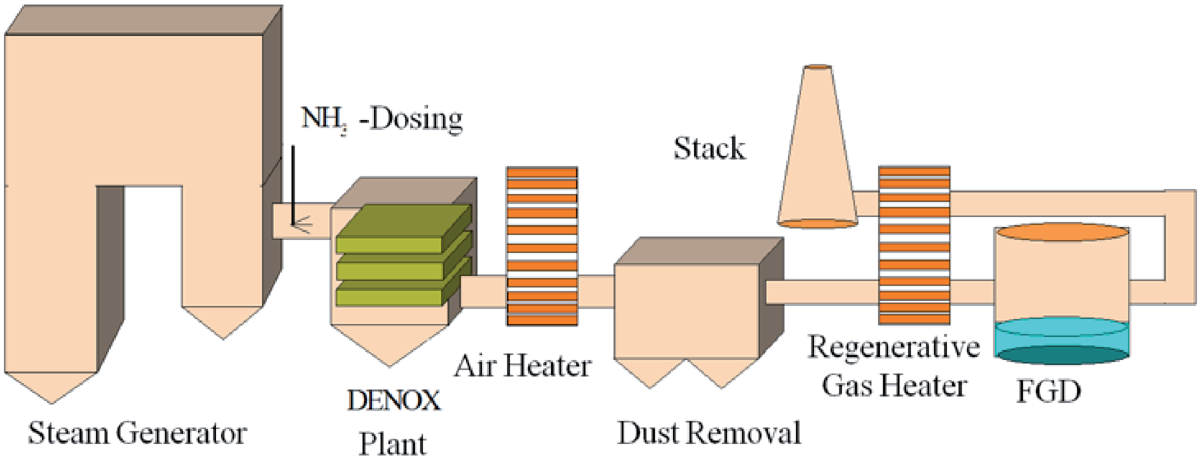
The next table shows the unit-wise breakdown of coal based capacity in India.

### Installed capacity in India as of March 2016

| Unit size | Installed before 31 Dec 2003 | | Installed after 31 Dec 2003 | |
|---|---|---|---|---|
| | No of Units | Total capacity (MW) | No of Units | Total capacity (MW) |
| Up to 250 MW | 313 | 47,628 | 112 | 19,214 |
| From 250 to 500 MW | 27 | 13,500 | 53 | 17,290 |
| More than 500 MW | - | - | 148 | 87,640 |
| Total | 340 | 61,128 | 313 | 124,144 |
| 653 units, capacity 185,272 MW (Coal) | | | | |

## Technology overview

The typical arrangement of the flue gas cleaning chain in German power plants is as follows:



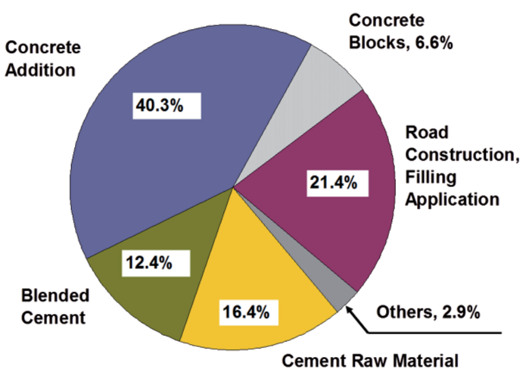

Source: VGB

The flue gas cleaning path usually includes:

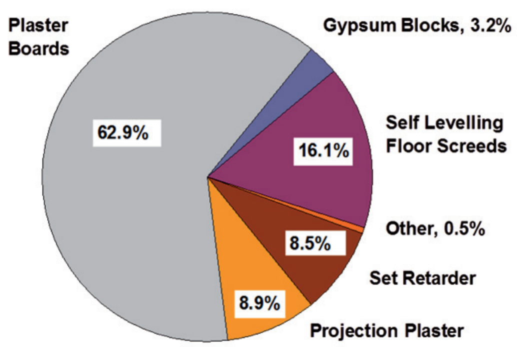
- a Selective Catalytic Reactor (SCR) for DeNOx in high-dust application (after the boiler, before the air pre-heater)
- dust removal – Electrostatic Precipitators (ESP) are the most common technology
- due to the higher sulfur content in the fuel wet limestone Flue Gas Desulfurization (FGD) is mainly applied for DeSOx

The majority of flue gas cleaning residuals of German and European power plants is utilised. The gypsum produced in a wet FGD is a saleable product in Germany. Most of it is utilised in the construction industry as shown in the following graph.

Utilisation of fly ash in the construction industry and in underground mining in Europe (EU 15) in 2013




Utilisation of FGD gypsum in the construction industry in Europe (EU 15) in 2013 (total utilisation 8.3 million tons)




Source: VGB

## DeNOx

Combustion optimisation is a necessary step that should always be completed first. It aims at:

- stable, monitorable flame
- high efficiency
  - low air ratio, even $O_2$ ratio
  - low un-burnt carbon in ash
  - low reheat spray
  - low exhaust gas temperature
  - low emissions (NOx)
- even distribution of flue gas temperature at furnace exit
- avoidance of flame impingement on the walls
- avoidance of slagging and fouling
- applicability of a wide coal range

The even distribution of coal to the individual burners plays a very important role. This can be ensured by: rotating classifiers, balancing of the coal flow to the burners, balancing the pressure drop of the coal pipes, and fine grinding.

Only after combustion optimization the appropriate DeNOx-technology should be selected. In some cases (e.g. most of the lignite-fired power plants in Germany) no additional technology is required to meet the emission limit requirements.

If additional technology is needed, the operator needs to decide between Selective Non-Catalytic Reduction (SNCR) or SCR technology. The following table shows the differences in the technologies.

### Comparison between SCR- and SNCR-technology

| SCR | SNCR |
|---|---|
| • NOx removal efficiency > 80%<br>• $NH_3$-Slip < 3 mg/Nm³<br>• additional fan capacity due to pressure loss at the catalyst, mixing, heat transfer system, flue gas ducts<br>• $SO_3$ reacts at low temperature to ammonium-bi-sulfate:<br>- icreasing of the pressure loss due to deposits<br>- corrosion<br>- negative impact on availability<br>• investment cost app. 5 to 10 times higher than for SNCR<br>• high operation costs<br>• high maintenance costs (fan, heat transfer system,<br>• catalyst regeneration/exchange)<br>• negative impact on the availability of the complete plant | • NOx removal efficiency max. 40–50%<br>• $NH_3$-Slip < 20 mg/Nm3<br>• higher reducing agents supply<br>• sometimes pollution of the fly ash or the by-product of the flue gas cleaning with ammonia<br>• less susceptible to faults because operating critical components are redundantly implemented<br>• low investment and operation costs<br>• nearly no expenses for maintenance |

Source: STEAG

The ammonia slip might not be a big issue for Indian coal. As it contains much more ash, the ammonia (slip) could serve as a flue gas conditioner making the existing ammonia-injection prior to the ESP obsolete.

If there is the need for high DeNOx efficiencies, SCR technology should be applied. The plate type catalyst would then be the first choice as it is suitable for high ash contents. For the SCR O&M it is important to know that the catalyst deactivation causes an ammonia slip whereas the NOx emission values remain stable. By monitoring the ammonia slip (via ash analysis) the deactivation of the catalyst can be anticipated. Activity tests and measurement of pressure loss of catalyst in a bench-scale reactor are also recommended.

## Particulate Matter

In order to check the status of the ESP, current-/ voltage-diagrams provide useful information about the current condition. They can be detected at the control cabinets of the ESP. An abnormal curve is a clear indicator of an ESP-dysfunction. The following principles should be considered:

- A certain discharge current is necessary to charge the particles and to collect them at the anode.
- Electric field strength must not be too high to allow for proper cleaning of the collecting electrode (anode)
- If dust resistivity is low, the current has to be increased.
- If dust resistivity is high, cthe current must be reduced to avoid back corona. A maximum current entry can be counterproductive and can result in reduced precipitation.

The following sequence of action is recommended for ESP optimisation:

1. Mechanical maintenance of the precipitator
2. Optimise of the combustion – firing and boiler operation
3. Homogenize the flue gas flow and distribution
4. Optimise high voltage units and controllers
5. Flue gas conditioning by $SO_3$ und $NH_3$
6. New interior / enlargement
7. Conversion to bag filter / hybrid precipitators (dry + wet)

Source: Uniper

## DeSOx

There are three technologies for flue gas desulphurization which are compared in the following table.

### Comparison of the different FGD types

| Parameter | Unit | Semi-dry FGD | Seawater FGD | Wet Limestone FGD |
|---|---|---|---|---|
| Suitability for high sulfur coals | | not economic | only with additives or fresh seawater | Yes |
| $SO_2$ removal efficiency | % | > 99 | > 99 | > 99 |
| $SO_3$ removal efficiency | % | > 99 | appr. 50 | appr. 50 |
| Absorbents | | lime | seawater | limestone / lime |
| Investment cost | % | 70 – 80 | 70 – 80 | 100 |
| Power consumption | % of TPP capacity | 1.0 – 1.5 | 0.8 – 1.5 | 1.0 – 2.0 |
| Maintenance | % | 80 | 30 | 100 |
| Absorbent costs | % | 200 | 0 | 100 |
| Residual | | dry calcium sulfite, calcium sulfate mixture | sulfate ions (dissolved in the seawater) | gypsum |
| Residual cost | | high disposal cost | none | saleable product |
| Suitability for units | MW | < 350 | up to 1,000 | up to 1,000 |
| Footprint | % | 50 | 50 – 70 | 100 |

Source: Doosan Lentjes

## Technology insights

The selection of the FGD-process depends on the site specifics. DeSOx-requirements, space availability as well as a concept for residuals are very important criteria.

The plant concept should consider:

- space requirements: the best place for installing a FGD is close to the boiler and to the stack
- most economical concept for consumables (i.e. lime or lime stone, grinding by supplier or within plant)
- most economical concept for gypsum (produce saleable gypsum which requires limestone purity of > 90% or mixing with ash for land filling)
- choice of the stack: wet stack with plume or dry stack (minimising water consumption)
- definition of availability and redundancy concept
- general quality requirements (automation concept, equipment specifications, insulation specifi-cations, etc.)

The input for the FGD-plant design has a huge effect on the cost. Therefore it is recommended using input data that are close to actual operation of the plant without large safety margins. This requires solid operation data of existing equipment (e.g. fans) as well as detailed information about their condition, expected lifetime and the corrosion status of installations.

Source: Steinmüller Babcock

## Mercury

Mercury is transferred completely into the gas phase during the combustion process. It occurs in elemental and oxidised form. Oxidised mercury can be more easily separated in the FGD unit. The Hg oxidation takes place mainly in the last catalyst layer of the SCR only under the presence of halides. Additive dosage before ESP enables improved deposition with the fly ash. Mercury separation in the FGD is favored by high chloride content. Additionally, precipitant agents improve the separation.

## Implementation recommendations at a glance

What needs to be done to adapt the power plant to new environmental norms?

### 1. Ensure maximum transparency about the power plant status

- coal quality and coal supply (condition of mills, grinding, coal piping, etc.)
- burners and air supply
- flue gas flow and distribution
- temperature profiles
- ash analysis
- raw emissions
- auxiliary power consumption
- heat rate

### 2. Optimise the combustion

- High efficiency of the combustion (low un-burnt carbon, low NOx emissions)
- Even distribution of flue gas temperature at furnace exit
- Avoidance of flame impingement on the walls
- Avoidance of slagging and fouling

### 3. Specify the flue gas cleaning requirements

- Removal efficiency for NOx, SOx and PM
- Space availability
- Standstill concept for erection
- Concept for the utilization and/or disposal of residuals

### 4. Derive the suitable DeNOx-technology

- Only necessary, if emission limit cannot be met by combustion optimization
- If 50% removal efficiency is sufficient, SNCR is the best choice – prepare for a test injection with ammonia
- If more removal efficiency is required, SCR is necessary – prepare for a laboratory test to define the optimum catalyst design

### 5. Optimise the ESP

- A good mechanical condition of the ESP, optimised combustion and transparency about all relevant data (flue gas distribution, temperature profiles, fly ash composition and distribution etc.) need to be the starting point of the activities.

### 6. Derive the suitable DeSOx-technology

- The selection of the FGD-technology depends on the site specifics: sulfur content of the coal, distance to the sea, space availability, removal efficiencies, etc.
- If wet limestone FGD is the option, a concept for utilising the gypsum should be developed.

### 7. Prepare a concept to train the power plant personnel

- There is a pressing need for training as the cleaning technologies are new equipment for the power plant. O&M has a tremendous impact on the operational cost and lifetime of the new plant components.

# Profiles of the German experts

## About Doosan Lentjes

Doosan Lentjes is a global provider of processes and technologies for energy production from both renewable and fossil fuels with the focus on APC (Air Pollution Control). The company's specific areas of expertise include circulating fluidised bed boilers, key technologies for the generation of energy from waste, and flue gas cleaning plants with a total installed capacity of almost 100 GWe. Doosan Lentjes' technologies have been pioneering energy solutions for 90 years. Doosan Lentjes is part of a powerful combination of companies united under the Doosan Group to deliver complementary technologies, skills and value to customers the world over. www.doosanlentjes.com

## About the speaker

Dr. Annette Ziemann-Nöthe graduated from the Technical University of Braunschweig with a PhD in technical chemistry. With a focus on research and development, Annette began her career in 1995 as a process engineer at Lentjes' predecessor, Gottfried Bischoff. Since 1998, she has worked as process engineer and project manager at Lentjes, was instrumental in managing the company's first seawater plant, and is now responsible as product manager for FGD (Flue Gas Cleaning) technologies.

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## About HAMON

HAMON, company founded in 1904, is an international engineering and contracting company, currently employs some 1737 people in 24 countries across the world.
HAMON provides equipment and aftermarket sales and services for Cooling Systems, Process Heat Exchangers, Air Quality Systems, Heat Recovery Steam Generators & Waste Heat Boilers. The services offered to customers include design, manufacture of certain key components, project management, on-site installation (including civil works in some cases), start-up and aftermarket service. www.hamon.com

## About the speaker

Christian Moser has been working for HAMON ENVIROSERV since 2006. For more than 20 years, he has been working for flue gas cleaning projects around the world. He gained his first professional experiences 1994 at Gottfried Bischoff company in Essen, being a leader in flue gas cleaning technologies and subsidiary of the Lurgi group. The focus of his business profession is process engineering of all the different technologies for flue gas desulphurization. As a managing director he is responsible for sales and engineering activities for the flue gas desulphrization technologies inside the HAMON Group.
Mr. Moser holds a diploma in process engineering.

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# Profiles of the German experts

## About STEAG Energy Services GmbH

STEAG Energy Services GmbH (SES) is a wholly owned subsidiary of STEAG GmbH, Germany's fifth-largest electricity generator. The company is headquartered in the city of Essen. The variety of our services reflects the complexity of a power plant. The portfolio comprises the full range of power plant related services, from efficient project management to IT solutions for optimization of costs and processes. The workforce covers the entire value chain from project planning through construction to operation o of a wide variety of energy generating facilities. www.steag-energyservices.com

### About the speaker

Matthias Schneider has been working for STEAG Energy Services GmbH since 2007. As deputy head of environmental technologies he is responsbile for engineering and consultancy services of flue gas cleaning systems for coal-fired power plants and combinedcycle plants, waste and biomass-fired plants and industrial power plants. The department covers solutions for flue gas particulate control, desulfurization (wet, semi-dry, dry systems) and $NO_x$ control (SCR/SNCR systems), $NH_3$ supply systems as well as solutions for dioxin, furan and heavy metal separation. The field of water treatment technologies is also part of the department. Matthias Schneider holds a diploma in process engineering.

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## About Steinmüller Babcock Environment GmbH

Steinmüller Babcock Environment GmbH (SBENG) has its seat in Germany near by the city of Cologne. The enterprise forms part of the worldwide active company Nippon Steel & Sumikin Engineering (NSENGI) from Japan. SBENG provides thermal waste treatment and flue gas cleaning plants based on all relevant technologies. The services include both retrofitting measures to existing systems and the construction and erection of complete new turn-key plants. In India SBENG has a close cooperation with its licensee for flue gas cleaning systems, The Indure Private Limited. www.steinmueller-babcock.com

### About the speaker

Dr. Frank Delle is working for as head of the Flue Gas Cleaning Division since 2012. He is responsible for all of SBENG'S gas cleaning technologies and activities. His professional career started 1993 with Lurgi in Frankfurt as process engineer for gas cleaning systems. For Lurgi he worked four years in Taiwan R.O.C. successfully executing a turn key Waste Incineration Plant. From 2002 he worked for Lurgi Lentjes, later Doosan Lentjes, in Ratingen, close to Düsseldorf, being responsible not only for Gas Cleaning but for CFB-boiler technologies as well; here he collected first personal experiences in cooperations with Indian power plant industry. Dr. Frank Delle holds his diploma in Process Engineering.

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# Profiles of the German experts

## About Uniper

Uniper is an international energy company with about14,000 employees, headquartered in Düsseldorf, Germany and active in more than 40 countries. With about 40 GWs of installed generating capacity, Uniper ranks among the large international power producers. Uniper offers a broad range of energy products, services, and solutions based on a deep understanding of global and regional energy markets, regulatory regimes, and market designs. It has a wide range of capabilities in the construction, management, and operation of large-scale energy assets. www.uniper.energy

## About the speaker

Dr. Dirk Porbatzki has been working for Uniper Technologies since 2008 in different positions. As a team leader of the internationally active catalyst management group and technical head of Uniper's Center of Competence Flue Gas Cleaning, he is responsible for flue gas cleaning projects within and outside of Uniper. Dr. Porbatzki started with an apprenticeship as industrial mechanic, holds a diploma in mineralogy and a docorate in mechanical engineering.

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## About VGB

VGB PowerTech e.V. is the European technical association for power and heat generation. Since its foundation in 1920, VGB has become the technical centre of competence for the operators.
The membership is open for companies and institutions active in the power business. 488 members in 35 countries – over 90 percent are European based – represent an installed of 461 gigawatt based on a broad energy mix and covering all sources of electricity production. www.vgb.org

## About the speaker

Dr. Claudia Weise has been working for VGB since 2008. As a project manager she is responsible for international projects ranging from technical consultancy to bilateral energy co-operation projects. She started her professional carreer at Siemens AG as a project engineer in the field of modernization of coal-fired power plants. Dr. Weise holds a diploma and a doctorate in process engineering.

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# About EEC

**EXCELLENCE ENHANCEMENT CENTRE (EEC)** for Indian Power Sector was conceptualized as a part of bilateral cooperation between Govt. of India and Govt. of Federal Republic of Germany and was set up through an Implementation Agreement between BEE & CEA, Ministry of Power, GOI and GIZ, Germany under the Indo German Energy Programme (Phase-II), to promote dialogue in the area of Energy Efficiency and Energy Security. It was registered as a non-profit society under the Indian Societies Registration Act 1860 and started functioning from February 2012.

## Aims and Objectives of EEC

- To provide a platform for the top Experts in Power Sector.
- To share best practices.
- To identify challenges.
- To create a "Technical Discussion Forum".
- To promote Peer to Peer cooperation between Indian Power Sector Stakeholders.
- To promote policy initiatives of MOP, GOI
- To raise awareness for the need of excellence in Power Sector

## Activities of EEC

- Making EEC more broad based
- Organizing an EEC Conference on annual basis
- Conducting 4-5 workshops every year
- Conducting 4-5 training programs every year
- Facilitating Knowledge Exchange
- Facilitating Technical Advice / Consultancy services
- Taking up Technical studies
- Creating an Archive of Best Practices,

## Governing Body of EEC*

President – Chairperson, CEA
Vice President – Member (Thermal), CEA
Member & Treasurer – Secretary, CBIP
Member – Director General, BEE
Member – Director (Technical), NTPC
Member Secretary – Chief Engineer (TPE&CC), CEA

Member – Dr. Ajay Mathur, Director General, TERI
Member – Dr. Winfried Damm, Director – IGEN, GIZ
Member – Dr. J.T. Verghese, Chairman, STEAG
Member – Shri D.K. Jain, Former Director (Tech.), NTPC
Member – Shri O.P. Maken, CEO, EEC

* Likely to be expanded to have wider representation of Power Sector Organisations

## Membership Fee Structure

| Category | Type of Organisations | Fees for 3 years Period** |
|---|---|---|
| A. | CPSUs/ IPPs/Private Sector Cos Manufacturers/Foreign Registered Companies (with gross annual turnover of more than 5000 Crs.) | ₹ 15 lakhs |
| B. | • CPSUs/ IPPs/Private Sector Cos Manufacturers/Foreign Registered Companies (with gross annual turnover of Rs.5000 Crs. Or Less)<br>• State Owned Utilities (Generation/Transmission/ Distribution/Trading)/State Boards/ Training Institute/Research Institutions/Academic Institutes/Govt. Agencies/Consultant etc. (Irrespective of turnover) | ₹ 6 lakhs |
| C. | Individuals | ₹ 6000/- |

**(The 3 years period is effective from payment of membership fee)

*Service Tax extra as applicable

## Benefits & Privileges of Three year EEC Membership - Kindly visit EEC Website

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