ODISHA POWER GENERATION CORPORATION LIMITED

BHUBANESWAR

OPGC

Power for Progress

ADDITIONAL SUBMISSION IN THE PETITION FOR APPROVAL OF CAPITAL COST AND TARIFF DETERMINATION FOR UNITS 3 & 4 (2x660 MW) FROM ANTICIPATED COD TO MARCH 31, 2019

MARCH, 2019

AFFIDAVIT

BEFORE THE ODISHA ELECTRICITY REGULATORY COMMISSION, BHUBANESHWAR

FILE NO. 2

CASE NO. ____ OF 2019

IN THE MATTER OF	Petition for Approval of Capital Cost and Tariff determination for Units 3 & 4 (2x660 MW) from anticipated COD to March 31, 2019

AND

IN THE MATTER OF THE APPLICANT	Odisha Power Generation Corporation Ltd. (OPGC Ltd.), Zone-A, 7th Floor, Fortune Towers, Chandrasekharpur, Bhubaneswar-751023, Odisha, India (Petitioner)

AND

IN THE MATTER OF	Additional submission in the Petition for Approval of Capital Cost and Tariff determination for Units 3 & 4 (2x660 MW) from anticipated COD to March 31, 2019

I, Ritwik Mishra, son of Shri. Muralidhar Mishra, aged about 50 years, do solemnly affirm and say as follows:

(a) That I am the General Manager (C&RA) of Odisha Power Generation Corporation Limited, the Petitioner in the above matter and am duly authorised by the said Petitioner to make this affidavit on its behalf.

(b) The additional submission with respect to OPGC's Petition for Approval of Capital Cost and Tariff determination for Units 3 & 4 (2x660 MW) from anticipated COD to March 31, 2019 are based on information provided to me and I believe them to be true to the best of my knowledge.

Verification

I, the deponent above named do hereby verify that the contents of my above affidavit are true to my knowledge; no part of it is false and nothing material has been concealed there from.

Verified at Bhubaneshwar on the 28th day of March, 2019.

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

Deponent

GOVT. OF ODISHA ★ NOTARY ★ PUSKAR SAHOO BHUBANESWAR REGD. NO.

BEFORE THE ODISHA ELECTRICITY REGULATORY COMMISSION, BHUBANESHWAR

CASE NO. ____ OF 2019

IN THE MATTER OF	Petition for Approval of Capital Cost and Tariff determination for Units 3 & 4 (2x660 MW) from anticipated COD to March 31, 2019

AND

IN THE MATTER OF THE APPLICANT	Odisha Power Generation Corporation Ltd. (OPGC Ltd.), Zone-A, 7th Floor, Fortune Towers, Chandrasekharpur, Bhubaneswar-751023, Odisha, India (Petitioner)

AND

IN THE MATTER OF	Additional submission in the Petition for Approval of Capital Cost and Tariff determination for Units 3 & 4 (2x660 MW) from anticipated COD to March 31, 2019

ODISHA POWER GENERATION CORPORATION LIMITED ("The Petitioner") RESPECTFULLY SUBMITS AS FOLLOWS:

Odisha Power Generation Corporation Limited (hereinafter referred as "OPGC" or "the Petitioner") is a company incorporated under the Companies Act, 1956 and having its registered office at Zone-A, 7th floor, Fortune Towers, Chandrasekharpur, Bhubaneswar, Odisha-751023.

OPGC, a generating company as defined in the Electricity Act, 2003, has an existing coal based thermal power station comprising of 2 Units of 210 MW capacity (Units 1 & 2), situated at IB Thermal Power Station Complex, Banharpalli, Jharsuguda District. OPGC is setting up 2 Units of 660 MW capacity (Units 3 & 4) as base load power plant, at the same site as that of the exiting plant.

NOTARY PUSKAR SAHOO BHUBANESWAR REGD. No. .../2009

ODISHA POWER GENERATION CORPORATION BHUBANESWAR

OPGC has filed the Petition for approval of Capital Cost and Tariff determination from anticipated COD of the plant to March 31, 2019, on January 19, 2019. OPGC hereby makes the following additional submission for kind consideration of the Hon'ble Commission.

The Environmental Clearance for OPGC Units 3 & 4 was accorded by the Ministry of Environment & Forests (MoEF) vide the letter dated February 4, 2010 under the then prevailing Environment (Protection) Rules, 1986. The Ministry of Environment, Forests & Climate Change (MoEF&CC) vide Notification dated 7 December, 2015 notified the Environment (Protection) Amendment Rules, 2015, thereby amending the Environment (Protection) Rules, 1986. The relevant extracts from the Notification (reproduced below) directs each Unit of thermal power stations to comply with the following:

"... (b) for serial number 25, and the entries related thereto, the following serial number and entries shall be substituted, namely:-

Sr.No.	***Industry***	***Parameter***	***Standards***
1	*2*	*3*	*4*
"25.	***Thermal Power Plant***	***……. TPPs (units) to be installed from 1st January, 2017*****	
		Particulate Matter	*30 mg/Nm^3*
		Sulphur Dioxide (SO_2)	*100 mg/Nm^3*
		Oxides of Nitrogen (NOx)	*100 mg/Nm^3*
		Mercury (Hg)	*0.03 mg/Nm^3*

… …

***Includes all the TPPs (units) which have been accorded environmental clearance and are under construction"*

The copy of the Environment (Protection) Amendment Rules, 2015 has been enclosed at **Annexure 1**.

In order to comply with the revised emission norms, SOx, NOx and Particulate Matter, the following technology/equipment need to be installed for Units 3 & 4:

NOTARY PUSKAR SAHOO BHUBANESWAR REGD. NO. 48/2009

POWER GENERATION CORPORATION BHUBANESWAR

a. Wet Flue Gas Desulphurisation (FGD) system, for controlling SOx emissions.

b. Selective Catalytic Reduction (SCR) system for controlling NOx emissions.

c. Flue Gas Conditioning (FGC) system for complying with emission norms of Suspended Particulate Matter (SPM).

The estimated capital expenditure on account of the above is as shown in the Table below:

Table 1: Estimated capital expenditure to meet the revised emission norms of MoEF&CC (Rs. Crore)

S. No.	Particulars	Estimated capital expenditure
1	Wet FGD system	985.55
2	SCR system	470.29
3	FGC system	35.36
4	**Total**	**1491.20**

The report for the feasibility study conducted for identification of the optimal method for complying with the revised emission norms of MoEF&CC is enclosed at **Annexure 2**.

This estimated capital expenditure for complying with the revised emission norms, is in addition to the total estimated capital expenditure submitted in the original Petition filed on January 19, 2019. OPGC has initiated the process for award of the contracts for procurement and installation of the above systems and shall be completed in due course of time. OPGC humbly requests the Hon'ble Commission to consider this additional capital expenditure in addition to the total estimated capital expenditure submitted in the original Petition filed on January 19, 2019. This additional capital expenditure shall not have any impact on the Tariff proposals of OPGC for FY 2018-19 in the original Petition, as this capital expenditure is proposed to be incurred during FY 2019-20.

NOTARY PUSKAR SAHOO BHUBANESWAR REGD. NO-48/2009 GOVT. OF ODISHA

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

Prayers to the Hon'ble OERC

OPGC respectfully prays that the Hon'ble OERC may:

i. Admit this additional submission;

ii. Consider this additional submission as an integral part of the original Petition filed on January 19, 2019;

iii. Condone any inadvertent omissions, errors, shortcomings and permit OPGC to add/ change/ modify/ alter this filing and make further submissions as may be required at a future date; and

iv. Pass such other and further Orders as deemed fit and proper in the facts and circumstances of the case.

Petitioner

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

Bhubaneshwar

March 28, 2019

28.3.2019

PUSKAR SAHOO
NOTARY, BHUBANESWAR
GOVT. OF ODISHA
Mob:-9337129137

NOTARY PUSKAR SAHOO BHUBANESWAR REGD. NO-48/2009 GOVT. OF ODISHA

ANNEXURE-I

रजिस्ट्री सं० डी० एल०-33004/99 REGD. NO. D. L.-33004/99

भारत का राजपत्र
The Gazette of India

असाधारण
EXTRAORDINARY
भाग II—खण्ड 3—उप-खण्ड (ii)
PART II—Section 3—Sub-section (ii)
प्राधिकार से प्रकाशित
PUBLISHED BY AUTHORITY

सं. 2620] नई दिल्ली, मंगलवार, दिसम्बर 8, 2015/अग्रहायण 17, 1937
No. 2620] NEW DELHI, TUESDAY, DECEMBER 8, 2015/AGRAHAYANA 17, 1937

पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय

अधिसूचना

नई दिल्ली, 7 दिसम्बर, 2015

का.आ. 3305(अ).— केंद्रीय सरकार, पर्यावरण (संरक्षण) अधिनियम, 1986 (1986 का 29) की धारा 6 और धारा 25 द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए पर्यावरण (संरक्षण) नियम, 1986 का और संशोधन करने के लिए निम्नलिखित नियम बनाती है, अर्थात् :—

1.(1) इन नियमों का संक्षिप्त नाम पर्यावरण (संरक्षण) संशोधन नियम, 2015 है ।

(2) ये उनके राजपत्र में प्रकाशन की तारीख को प्रवृत्त होंगे ।

2. पर्यावरण (संरक्षण) नियम, 1986 की अनुसूची 1 में,—

(क) क्रम सं. 5 और उससे संबंधित प्रविष्टियों के स्थान पर निम्नलिखित क्रम सं. और प्रविष्टियां अंत:स्थापित की जाएंगी, अर्थात् :—

क्रम सं.	उद्योग	मापदंड	मानक
1	2	3	4.
5क	ताप विद्युत संयंत्र (जल उपभोग सीमा)	जल उपभोग	1. एक बार शीतलन (ओटीसी) के माध्यम से सभी संयंत्र शीतलन टावरों (सीटी) को प्रतिष्ठापित करेंगे और अधिसूचना की तारीख से दो वर्ष की अवधि के भीतर अधिकतम 3.5m³/MWh के विनिर्दिष्ट जल उपभोग को हासिल करेंगे ।

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			II. सभी विद्यमान सीटी-आधारित संयंत्र 3.5m³/MWh इस अधिसूचना के प्रकाशन की तारीख से दो वर्ष के भीतर अधिकतम 3.5m³/MWh तक के विनिर्दिष्ट जल उपभोग को कम करेंगे। III. जनवरी, 2017 के पश्चात् प्रतिष्ठापित किए जाने वाले नए संयंत्र अधिकतम 2.5 m³/MWh तक के विनिदिष्ट जल उपभोग को पूरा करेंगे और शून्य जल दुर्व्यय को हासिल करेंगे।

(ख) क्रम सं. 25 और उससे संबंधित प्रविष्टियों के पश्चात् निम्नलिखित क्रम सं. और प्रविष्टियां रखी जाएंगी, अर्थात् :—

क्रम सं.	उद्योग	मापदंड	मानक
1	2	3	4
		विविक्त पदार्थ	100 mg/Nm³
		सल्फर डायोक्साइड(SO_2)	600 mg/Nm³ (500 मेगावाट से कम क्षमता की इकाईयों से लघु इकाईयां) 200 mg/Nm³ (500 मेगावाट और उससे अधिक क्षमता की इकाईयां)
		नाइट्रोजन के आक्साइड (NOx)	300 mg/Nm³
		पारा (Hg)	0.03 mg/Nm³ (500 मेगावाट और उससे अधिक क्षमता की इकाईयां)
		1 जनवरी, 2003 के पश्चात् 31 दिसंबर, 2016" तक प्रतिष्ठापित टीपीपी (इकाईयां)	
		विविक्त पदार्थ	50 mg/Nm³
		सल्फर डायोक्साइड (SO_2)	600 mg/Nm³ (500 मेगावाट से कम क्षमता की इकाईयों से लघु इकाईयां) 200 mg/Nm³ (500 मेगावाट और उससे अधिक क्षमता की इकाईयां)
		नाइट्रोजन के आक्साइड (NOx)	300 mg/Nm³
		पारा (Hg)	0.03 mg/Nm³
		1 जनवरी, 2017" से प्रतिष्ठापित टीपीपी (इकाईयां)	
		विविक्त पदार्थ	30 mg/Nm³
		सल्फर डायोक्साइड (SO_2)	100 mg/Nm³
		नाइट्रोजन के आक्साइड	100 mg/Nm³

		(NOx)	
		पारा (Hg)	0.03 mg/Nm³

* टीपीपी (इकाईयां) इस अधिसूचना के प्रकाशन की तारीख से दो वर्ष के भीतर परिसीमाओं को पूरा करेंगी।

** इसके अंतर्गत सभी टीपीपी (इकाईयां) हैं, जिन्हें पर्यावरणीय निकासी प्रदान की गई है और संनिर्माण के अधीन है।

[फा. सं. क्यू-15017/40/2007-सीपीडब्ल्यू]

डा. राशिद हसन, सलाहकार

टिप्पण :- मूल नियम भारत के राजपत्र, असाधारण, भाग II, खंड 3, उपखंड (ii) में सं. का.आ. 844(अ) 19 नवंबर, 1986 द्वारा प्रकाशित किए गए थे और उनका पश्चातवर्ती का.आ. 433(अ) तारीख 18 अप्रैल, 1987 ; सा.का.नि 176(अ) तारीख 2 अप्रैल, 1996; सा.का.नि. 97 (अ), तारीख 18 फरवरी, 2009 ; सा.का.नि 149(अ) तारीख 4 मार्च, 2009 ; सा.का.नि. 543(अ) तारीख 22 जुलाई, 2009 ; सा.का.नि. 739(अ) तारीख 9 सितम्बर, 2010 ; सा.का.नि. 809(अ) तारीख 4 अक्टूबर, 2010, सा.का.नि. 215(अ) तारीख 15 मार्च, 2011 ; सा.का.नि. 221(अ) तारीख 18 मार्च, 2011 ; सा.का.नि. 354(अ) तारीख 2 मई, 2011 ; सा.का.नि. 424(अ) तारीख 1 जून, 2011 ; सा.का.नि. 446(अ) तारीख 13 जून, 2011 ; सा.का.नि. 152(अ) तारीख 16 मार्च, 2012 ; सा.का.नि. 266(अ) तारीख 30 मार्च, 2012 ; सा.का.नि. 277(अ) तारीख 31 मार्च, 2012; सा.का.नि. 820(अ) तारीख 9 नवम्बर, 2012 ; सा.का.नि. 176(अ) तारीख 18 मार्च, 2013 ; सा.का.नि. 535(अ) तारीख 7 अगस्त, 2013 ; सा.का.नि. 771(अ) तारीख 11 दिसम्बर, 2013 ; सा.का.नि. 2(अ) तारीख 2 जनवरी, 2014 ; सा.का.नि. 229(अ) तारीख 28 मार्च, 2014 ; सा.का.नि. 232(अ) तारीख 31 मार्च, 2014 ; सा.का.नि. 325(अ) तारीख 7 मई, 2014, सा.का.नि. 612(अ) तारीख 25 अगस्त, 2014 और अन्तिम संशोधन सा.का.नि. 789(अ) तारीख 11 नवम्बर, 2014 किया गया था।

MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

NOTIFICATION

New Delhi, the 7th December, 2015

S.O. 3305(E).— In exercise of the powers conferred by sections 6 and 25 of the Environment (Protection) Act, 1986 (29 of 1986), the Central Government hereby makes the following rules further to amend the Environment (Protection) Rules, 1986, namely:–

1. (1) These rules may be called the Environment (Protection) Amendment Rules, 2015.

(2) They shall come into force on the date of their publication in the Official Gazette.

2. In the Environment (Protection) Rules, 1986, in Schedule – I, -

(a) after serial number 5 and entries relating thereto, the following serial number and entries shall be inserted, namely:–

Sr. No.	Industry	Parameter	Standards
1	2	3	4
"5A.	Thermal Power Plant (Water consumption limit)	Water consumption	I. All plants with Once Through Cooling (OTC) shall install Cooling Tower (CT) and achieve specific water consumption upto maximum of 3.5m³/MWh within a period

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BHUBANESWAR

			of two years from the date of publication of this notification. II. All existing CT-based plants reduce specific water consumption upto maximum of $3.5m^3$/MWh within a period of two years from the date of publication of this notification. III. New plants to be installed after 1st January, 2017 shall have to meet specific water consumption upto maximum of 2.5 m^3/MWh and achieve zero waste water discharged";

(b) for serial number 25, and the entries related thereto, the following serial number and entries shall be substituted, namely:-

Sr. No.	Industry	Parameter	Standards
1	2	3	4
"25.	Thermal Power Plant	TPPs (units) installed before 31st December, 2003*	
		Particulate Matter	100 mg/Nm^3
		Sulphur Dioxide (SO_2)	600 mg/Nm^3 (Units Smaller than 500MW capacity units) 200 mg/Nm^3 (for units having capacity of 500MW and above)
		Oxides of Nitrogen (NOx)	600 mg/Nm^3
		Mercury (Hg)	0.03 mg/Nm^3(for units having capacity of 500MW and above)
		TPPs (units) installed after 1st January,2003, upto 31st December, 2016*	
		Particulate Matter	50 mg/Nm^3
		Sulphur Dioxide (SO_2)	600 mg/Nm^3 (Units Smaller than 500MW capacity units) 200 mg/Nm^3 (for units having capacity of 500MW and above)
		Oxides of Nitrogen (NOx)	300 mg/Nm^3
		Mercury (Hg)	0.03 mg/Nm^3
		TPPs (units) to be installed from 1st January, 2017**	
		Particulate Matter	30 mg/Nm^3
		Sulphur Dioxide (SO_2)	100 mg/Nm^3
		Oxides of Nitrogen (NOx)	100 mg/Nm^3
		Mercury (Hg)	0.03 mg/Nm^3

*TPPs (units) shall meet the limits within two years from date of publication of this notification.

**Includes all the TPPs (units) which have been accorded environmental clearance and are under construction".

[F. No. Q-15017/40/2007-CPW]

Dr. RASHID HASAN, Advisor

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

Note: - The principal rules were published in the Gazette of India, Extraordinary, Part II, Section 3, Sub-section (i) *vide* number S.O. 844(E), dated the 19th November, 1986 and subsequently amended *vide* the following notifications:—

S.O. 433(E), dated 18th April 1987; G.S.R. 176(E) dated 2nd April, 1996; G.S.R. 97(E), dated the 18th February, 2009; G.S.R. 149(E), dated the 4th March , 2009; G.S.R. 543(E), dated 22nd July, 2009; G.S.R. 739(E), dated the 9th September, 2010; G.S.R. 809(E), dated, the 4th October, 2010, G.S.R. 215(E), dated the 15th March, 2011; G.S.R. 221(E), dated the 18th March, 2011; G.S.R. 354(E), dated the 2nd May, 2011; G.S.R. 424(E), dated the 1st June, 2011; G.S.R. 446(E), dated the 13th June, 2011; G.S.R. 152(E), dated the 16th March, 2012; G.S.R. 266(E), dated the 30th March, 2012; and G.S.R. 277(E), dated the 31st March, 2012; and G.S.R. 820(E), dated the 9th November, 2012; G.S.R. 176(E), dated the 18th March, 2013; G.S.R. 535(E), dated the 7th August, 2013; G.S.R. 771(E), dated the 11th December, 2013; G.S.R. 2(E), dated the 2nd January, 2014; G.S.R. 229(E), dated the 28th March, 2014; G.S.R. 232(E), dated the 31st March, 2014; G.S.R. 325(E), dated the 07th May, 2014, G.S.R. 612,(E), dated the 25th August, 2014 and lastly amended vide notification G.S.R. 789(E), dated 11th November, 2014.

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

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रजिस्ट्री सं० डी० एल०-33004/99

REGD. NO. D. L.-33004/99

भारत का राजपत्र
The Gazette of India

असाधारण

EXTRAORDINARY

भाग II—खण्ड 3—उप-खण्ड (ii)

PART II—Section 3—Sub-section (ii)

प्राधिकार से प्रकाशित

PUBLISHED BY AUTHORITY

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No. 590] NEW DELHI, MONDAY, MARCH 7, 2016/PHALGUNA 17, 1937

पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय

शुद्धिपत्र

नई दिल्ली, 7 मार्च, 2016

का.आ. 682(अ).—भारत के राजपत्र में प्रकाशित पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय की अधिसूचना सा.का.नि. 3305(अ) तारीख 7 दिसंबर, 2015 द्वारा अधिसूचित पर्यावरण (संरक्षण) संशोधन नियम, 2015 के अंतर्गत आने वाली नीचे उल्लिखित प्रविष्टियों को निम्न पढ़ें:

1. पृष्ठ सं. 2, क्रम सं. 25, पंक्ति सं. 2 के नीचे सारणी में स्तम्भ 3 और 4 में "31 **दिसंबर**, 2003 **से पहले संस्थापित टीपीपी (इकाईयां)"**

2. पृष्ठ सं. 2, क्रम सं. 25, पंक्ति सं. 6 की सारणी के स्तम्भ 4 में "300 mg/Nm³" के स्थान पर "600 mg/Nm³" पढ़ें

3. पृष्ठ सं. 2, क्रम सं. 25, पंक्ति सं. 8 की सारणी के स्तम्भ 3 और 4 में "1 जनवरी, 2003" के स्थान पर "1 **जनवरी**, 2004" पढ़ें

[फा.सं. क्यू.15017/40/2007-सीपीडब्ल्यू]

डा. राशिद हसन, सलाहकार

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

CORRIGENDUM

New Delhi, the 7th March, 2016

S.O. 682(E).—In the notification of the Government of India in the Ministry of Environment, Forest and Climate Change vide number S.O. 3305(E), dated the 7^{th} December, 2015, published in the Gazette of India, Part II, Section 3, Sub-section (ii), in page 4, in the Table, against serial number 25, for "1^{st} January, 2003" substitute "1^{st} January, 2004".

[F.No. Q-15017/40/2007-CPW]

Dr. RASHID HASAN, Advisor

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ANNEXURE-II

THE FEASIBILITY REPORT FOR PM, SO_2 AND NO_X COMPLIANCE WITH CATEGORY 3 EMISSION NORMS – MODULE III

IB Thermal Power Station

BLACK & VEATCH PROJECT NO. 192529

PREPARED FOR

ODISHA POWER GENERATION CORPORATION LIMITED

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1.0 Executive Summary

Odisha Power Generation Corporation (OPGC) Limited established IB Thermal Power Station comprising of two units of 210MW each in the IB valley area of Banaharpalli in Jharsuguda District in the State of Odisha. These units have become operational since 1994 (1st Unit) and 1996 (2nd Unit) respectively and are identified as OPGC I. Additionally, the construction of two units of 1,320(2x660) MW capacity has commenced at the same location adjacent to the existing plant which may be operational in mid-2018. These units are identified as OPGC II.

Black &Veatch has been appointed by OPGC as the environment consultant for providing technical consulting services required for compliance with the revised Ministry of Environment, Forest and Climate Change (MoEFCC) emission norms. The objective of this study is to conduct feasibility study for OPGCII for SO_2, PM and NOx compliance with Category3 emission norms and to identify the best method of emissions reduction for pollutants by giving due consideration to the synergies possible by leveraging common facilities with OPGC I project as well to minimize the space requirement and optimize the cost. Black & Veatch observations and recommendations are as follows:

- After comparing different SO_2 emission control technologies for OPGC II, Black & Veatch recommends installing Wet FGD system for meeting the new SO_2 target limits.
- OPGC II will be able to meet the new target PM limits with the implementation and utilization of flue gas conditioning (FGC) system.
- After comparing different NOx emission control technologies for OPGC II, Black & Veatch recommends installing high-dust SCR system utilizing anhydrous ammonia as reagent for meeting the new NOx target limits.
- OPGC II may be achieving Hg compliance based on the coal proposed for firing and no further reduction of Hg may be required.

2.0 Introduction

2.1 PROJECT BACKGROUND

Ministry of Environment, Forest and Climate Change (MoEFCC) issued a notification (S.O. 3305(E) on 7th December 2015), that sets new standards for air emissions and water consumption for the coal-based thermal power units. The new emissions standards include not only stringent limits for Particulate Matter (PM) emissions but also include stringent limits for oxides of nitrogen (NOx), sulfur dioxide (SO_2) and mercury (Hg) emissions. Table 2-1 depicts the new emission limits specified by MoEFCC.

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Table 2-1 **New Emission Limits**

PARTICULARS	THERMAL POWER PLANTS		
Pollutants	CATEGORY1 Installed Before 31st Dec 2003	CATEGORY2 Installed or to be commissioned between 1st Jan 2004 and 31st Dec 2016	CATEGORY3 To be commissioned on and after 1st January, 2017
Particulate Matter(PM)	100mg/Nm³	50mg/Nm³	30mg/Nm³
Sulphur Dioxide(SO_2)	600mg/Nm³ (Units Smaller than 500MW capacity units) 200mg/Nm³ (for units having capacity of 500MW and above)	600mg/Nm³ (Units Smaller than 500MW capacity units) 200mg/Nm³ (for units having capacity of 500MW and above)	100mg/Nm³
Oxides of Nitrogen (NOx)	600mg/Nm³	300mg/Nm³	100mg/Nm³
Mercury(Hg)	0.03mg/Nm³ (for units having capacity of 500MW and above)	0.03mg/Nm³	0.03mg/Nm³

The units are categorized into three categories based on the installation dates. Category1 is for units installed before December 31, 2003 and the operational thermal power plant, OPGC I, of IB Thermal Power Station (2x210MW) will fall under Category1. The under construction thermal power plant, OPGC II, of IB Thermal Power Station (2 x 660 MW) will come under the Category3 of the new emission standards.

The notification for new standards also sets new limits for water consumption for the coal-based thermal power sector, as shown in Table 2-2. Based on the new limits, OPGC II will have to restrict the water consumption to3.0 m³/MW hand will have to achieve zero liquid discharge (ZLD).

Table 2-2 **Water Consumption Limits**

INDUSTRY	PARAMETER	STANDARDS
Thermal Power Plant	Water Consumption	1. All plants with once-through cooling (OTC) shall install cooling towers (CTs) and achieve a specific water consumption maximum of 3.5 cubic meters per mega watt-hour (m³/MWh) within 2 years from the date of publication of this notification.
		2. All existing CT-based plants shall reduce specific water consumption upto maximum of 3.5m³/MWh within 2years from the date of publication of this notification.
		3. New plants to be installed after January 1, 2017, shall meet the specific water consumption limitations upto a maximum of 2.5m³/MWh and achieve zero liquid discharge(ZLD).

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In view of this notification, OPGC needs its units to be assessed on compliance status and plan for addressing the gaps in compliance for both operational plant and plant under construction. Black & Veatch has been appointed by OPGC as an environment consultant for providing technical consulting services required for compliance with revised emission norms.

This report is intended to provide OPGC with the necessary information needed to select the most appropriate SO_2, PM and NOx removal technologies that addresses it e-specific considerations and supports the project objectives of fuel flexibility and emissions control requirements as set forth by MoEFCC.

2.2 BASE LINE EMISSION OF OPGC II

Black & Veatch performed combustion calculation using in-house proprietary software models which utilize ASME PTC codes, industry standards, and other analyses in order to calculate the flue gas flow rates, fuel burn rates, and several other outputs. The complete base line emission report is included in Appendix A.

Based on the established flue gas flow rates, base line emissions for OPGC II Units3 and 4 were derived, which are shown in the Table 2-3. Both the units are not compliant in terms of SO_2, PM and NO_X emissions with both worst coal and design coal, but are meeting the Hg emission limits.

Table 2-3 **Current Pollutants Emission for OPGC II**

POLLUTANTS	UNIT3 DESIGN COAL	UNIT4 DESIGN COAL	EMISSION LIMITS FOR CATEGORY3 UNITS
PM,mg/Nm^3@6%O_2 dry	50	50	30
SO_2,mg/Nm^3@6%O_2 dry	2,274	2,274	100
NOx,mg/Nm^3@6%O_2 dry	692	692	100
Hg,mg/Nm^3@6%O_2 dry	0.029	0.029	0.03

Note: The PM emission values for OPGC II are based on one ESP field out of service. OPGC II may achieve 30mg/Nm^3 of PM emissions for design coal with all ESP fields in service. However, with continuous operation of ESP, the PM emission levels will increase due to change in operating conditions and deterioration of ESP infrastructure.

2.3 TARGET EMISSIONS OF OPGC II

Based on the evaluation report for Module I and as per Table 2-4, only SO_2, PM and NO_X reduction is required for OPGC II. Hg reduction is not required for OPGC II.

Table 2-4 **Pollutants Percentage Reduction Required for OPGC II**

POLLUTANTS	UNIT3 DESIGN COAL	UNIT4 DESIGN COAL
PM, %Reduction Required	40	40
SO2, %Reduction Required	96	96
NOx, %Reduction Required	86	86
Hg, %Reduction Required	Not Required	Not Required

SO_2, PM and NO_X control technology/ equipment needs to be installed for Units 3 and 4 of OPGC

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II. This document covers the feasibility study carried out for SO_2, PM and NO_X compliance as required under Category 3, for OPGC II.

3.0 Design Basis

A detailed set of design basis was established for OPGC II based on information provided by OPGC and results from Black & Veatch internal combustion calculations. The information in the design basis has been used for equipment sizing, performance calculations, cost estimates (capital, operating and maintenance), and estimating resource consumption, auxiliary power requirements and byproduct disposal. Performance calculations and capital cost estimations are based on the design basis with worst coal and the estimation for annual operating and maintenance (O&M) costs are based on the design basis with design coal.

OPGC Units 3 and 4 (2 x660 MW) are super-critical, tangential fired boilers that operates on balanced draft conditions. The boiler of each unit is equipped with two rotary regenerative air heaters, two forced draft fans, and two induced draft fans. For emissions reduction, each unit is equipped with Low NOx Burners (LNB), Separated Over fire Air(SOFA), Closed Coupled Over fire Air (CCOFA)and a cold-side Electrostatic Precipitator (ESP).

Table 3-1 represents the coal analyses which were used to develop combustion air and flue gas flow rates for units of OPGCII.

Table 3-1 Coal Analysis for OPGC II

PARAMETERS	DESIGN COAL
Carbon,%	33.74
Hydrogen,%	2.09
Sulfur,%	0.60
Nitrogen,%	0.45
Oxygen,%	5.70
Moisture,%	13.70
Ash,%	43.70
Chlorine, ppm	200
Mercury, ppm	0.015
Higher Heating Value, Kcal/Kg	2,998

A summary of boiler system operating conditions for OPGC II is presented in Table 3-2.

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Table 3-2 Boiler System Operating Conditions for OPGC-II

PARAMETERS	UNIT3/UNIT4 DESIGN COAL
Unit Operating Characteristics	
Fuel Mass Flow, kg/s	140.72
Fuel Heat Input, GJ/hr	6,358.76
Excess Air,%	20.00
Air Heater Leakage, %	10.00

Table3-3 below shows the flue gas conditions at the outlet of ID fan for OPGC II Units3 and 4.

Table 3-3 Draft System Operating Conditions for OPGC II

PARAMETERS	UNIT3/UNIT4 DESIGN COAL
Gas Leaving I.D. Fans	
Mass Flow (Total Wet Flue Gas), kg/s	908.81
Volumetric Flow (Total Wet Flue Gas), m^3/s	1,063.07
Temperature, deg C	135.46
Pressure, kpa (g)	0.46
Particulate Matter, $mg/Nm^3@6\%O_2$	50
Sulfur Dioxide, $mg/Nm^3@6\%O_2$	2,274
Oxides of Nitrogen, $mg/Nm^3@6\%O_2$	692
Mercury, $mg/Nm^3@6\%O_2$	0.029

4.0 Technology Selection for OPGC-II

4.1 SO_2 Control Technologies

SO_2 control technologies that were identified as available for retrofit at OPGC II are listed below:

- Coal Washing
- Wet lime stone based Flue Gas Desulfurization(WFGD)
- Ammonia based Flue Gas Desulfurization (AFGD)
- Sea Water Flue Gas Desulfurization (SWFGD)
- Semi-Dry Flue Gas Desulfurization (SDFGD)
- Multi-Pollutant Removal System

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Technology Considered – Wet Limestone-Based FGD Process:

Wet lime stone-based FGD processes are frequently applied to pulverized coal fired boilers that combust medium-to-high sulfur coals. Typically, the wet FGD processes on a pulverized coal facility are characterized by high efficiency (> 98 percent) and high reagent utilization (95 to 97 percent) when combined with a high sulfur fuel. The ability to realize high removal efficiencies on higher sulfur fuels is a major difference between wet scrubbers and semi-dry FGD processes. It is well known that SO_2 removal efficiencies for wet FGD systems are generally higher for high sulfur coal applications than for low sulfur coal applications, for the fundamental physical reason that the chemical reactions that remove SO_2 are faster if the inlet SO_2 concentration is higher. The absolute emissions level becomes a limiting factor due to a reduction in the chemical driving forces of the reactions that are occurring. Thus, the calculated removal efficiency of the various types of wet scrubbers declines as the fuel sulfur content decreases.

In a wet FGD system, the absorber module is located downstream of the induced draft (ID) fans (or booster ID fans, if required). Flue gas enters the module and is contacted with slurry containing reagent and byproduct solids. The SO_2 is absorbed into the slurry and reacts with the calcium to form $CaSO_3$. $\frac{1}{2}H_2O$ and $CaSO_4$. $2H_2O$.SO_2 reacts with limestone reagent through the following overall reactions:

$$SO_2 + CaCO_3 + \tfrac{1}{2}H_2O \rightarrow CaSO_3.\tfrac{1}{2}H_2O + CO_2$$

$$SO_2 + CaCO_3 + 2H_2O + \tfrac{1}{2}O_2 \rightarrow CaSO_4.2H_2O + CO_2$$

There are several types of wet absorber modules, and each has characteristic advantages and disadvantages. FGD equipment vendors have specific designs for one or more types, and all compete on a capital and operating cost basis. Depending on the process vendor, the absorber may be a co-current or counter current spray tower, with or without internal packing or trays, or a process in which the flue gas is bubbled into the reaction tank (commonly referred to as a jet bubbling reactor (JBR)).

Regardless of the type of absorber used, the flue gas leaving the absorber will be saturated with water, and the stack will have a visible moisture plume. Because of the chlorides present in the mist carry-over from the absorber and the pool so flow pH condensate that can develop, the conditions downstream of the absorber are highly corrosive to most materials of construction. Highly corrosion-resistant materials are required for the downstream ductwork and the flue stack. Careful design of the stack is needed to prevent the "rainout" from condensation that occurs in the downstream ductwork and stack. These factors contribute to the relatively high capital costs of the wet FGD SO_2 control alternative.

The reaction products are typically dewatered by a combination of hydro cyclones and vacuum filters. The resulting filter cake is suitable for land fill disposal. In early lime-based and lime stone-based FGD processes, the byproduct solids were primarily calcium sulfite hemihydrates ($CaSO_3.\frac{1}{2}H_2O$), and the byproduct solids were mixed with fly ash (stabilization) or fly ash and lime(fixation) to produce a physically stable material. In the current generation of wet FGD systems, air is bubbled through the reaction tank (or in some cases, a separate vessel) to practically convert all of the $CaSO_3.\frac{1}{2}H_2O$ into calcium sulfate dihydrate ($CaSO_4.2H_2O$), which is commonly known as gypsum. This step is termed "forced oxidation" and has been applied to both lime-based and limestone-based FGD processes. Compared to calcium sulfite hemihydrate, gypsum has much superior dewatering and physical properties, and forced oxidized FGD systems tend to have few internal scaling problems in the absorber and mist eliminators. Dewatered gypsum can be land filled without stabilization or fixation. If the lime stone qu[illegible]more than 95% $CaCO_3$

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content the forced-oxidation process can produce a commercial grade of gypsum that can be used in the production of Port land cement or wallboard. Marketing of the gypsum can eliminate or greatly reduce the need to landfill FGD byproducts.

The absorber vessels are fabricated from corrosion-resistant materials such as epoxy/ vinyl ester-lined carbon steel, rubber-lined carbon steel, stainless steel, or fiber glass. The absorbers handle large volumes of abrasive slurries. The byproduct dewatering equipment is also relatively complex and expensive. These factors result in relatively higher initial capital costs. Wet FGD processes are also characterized by higher raw water usage than Semi-Dry FGD systems. This can be a significant disadvantage or even a fatal flaw in areas where raw water availability is in short supply.

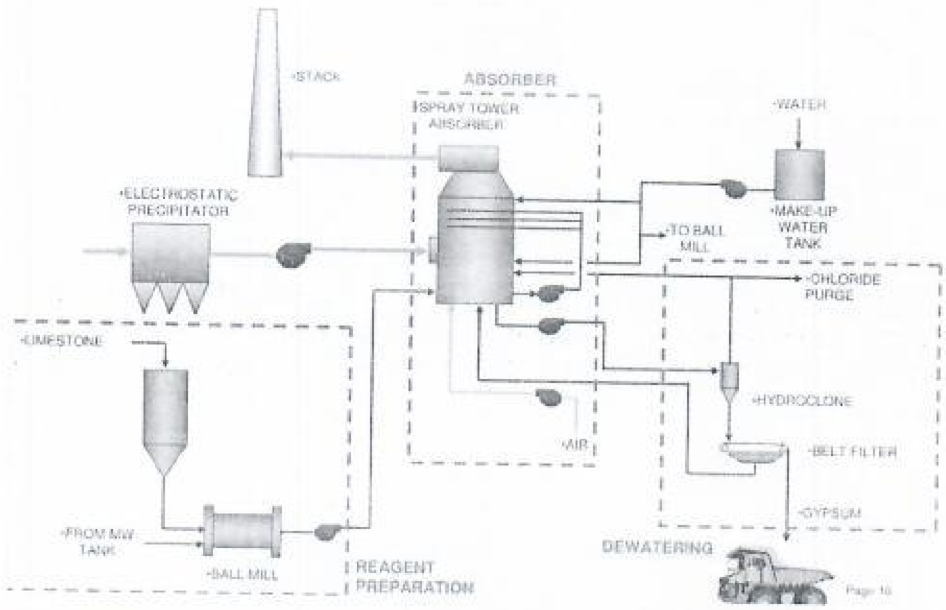

Figure 4-1 Process Flow Diagram of a Spray Tower Wet FGD System (Source:GE)

4.2 NOx Control Technologies

NOx control technologies that were identified as available for retrofit at OPGC II are listed below:

- Over fire Air(OFA)
- Neural Networks(NN)
- Oxygen Enhanced Combustion
- New Low NOx Burners(LNB)
- Boiler Tuning
- Natural Gas Reburn
- Mobotec
- Rich Reagent Injection
- LoTOx
- THERMALONOx Process
- NOxSTAR™

- Selective Non Catalytic Reduction (SNCR)
- Selective Catalytic Reduction(SCR)
- Induct Hybrid Selective Catalytic Reduction
- Multi pollutant Control Technologies

Technology Considered –Selective Catalytic Reduction:

Selective Catalytic Reduction (SCR) systems are the most widely used post-combustion NOx control technology for achieving significant reductions in NOx emissions. In SCR systems, vaporized ammonia (NH_3) injected into the flue gas stream acts as a reducing agent, achieving NOx emission reductions as low as 0.06lb/MBtu when passed over an appropriate amount of catalyst. The NOx and ammonia reagent react to form nitrogen and water vapor. The reaction mechanisms are very efficient with a reagent stoichiometry of approximately 1.05 (on a NOx reduction basis) with very low ammonia slip (unreacted ammonia emissions). A simplified schematic diagram of a typical SCR reactor is illustrated in Figure 4-18. However, most modern SCR systems are built without a bypass systems and sonic horns are used in place of steam or air soot blowers.

The SCR reactor is the housing for the catalyst. The reactor is basically a widened section of duct work modified by the addition of gas flow distribution devices, catalyst, catalyst support structures, access doors, and soot blowers. An ammonia injection grid is located upstream of the SCR reactor and the system can be designed with or without a flue gas bypass. The SCR reactor is typically elevated above and behind the air heater and downstream emissions control equipment (typically an ESP) and gas flow direction through the reactor is vertically downward for coal fired applications. In a "high-dust" SCR arrangement, the reactor is located between the outlet of the economizer and the inlet of the air heater. The high-dust system is typically the most economical and preferred arrangement where physically possible.

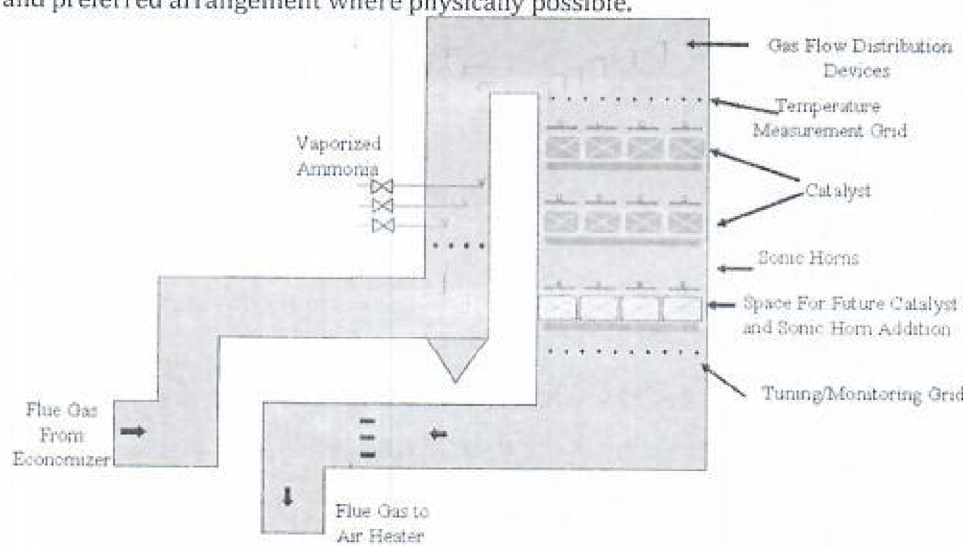

Figure4-2 Schematic Diagram of a Typical SCR Reactor

The SCR reaction occurs within the temperature range of 550°F to 850°F (287-454°C) where the extremes are highly dependent on the fuel quality. The oxidation of SO_2 to SO_3 could also require moderate air heater modifications since the acid dew point temperature of the flue gas is directly related to SO_3 concentration. As the SO_3 concentration increases, the acid dew point of the flue gas increases, potentially increasing corrosion in downstream equipment possibly requiring an

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increase in the air heater gas outlet temperature.

The ammonia reagent for the SCR systems can be supplied by anhydrous ammonia, aqueous ammonia, or by conversion of urea to ammonia. Since the ammonia is vaporized prior to contact with the catalyst, the selection of ammonia type does not influence the catalyst performance. However, the selection of ammonia type does affect all other subsystem components, including reagent storage, vaporization, injection control, and balance-of-plant requirements.

SCR systems have a variety of interfacing system requirements to support operations. These impacts predominately relate to draft, auxiliary power, soot blowing steam, gas temperature, controls, duct work, reactor foot print, and air heater. The SCR system will impact the boiler draft system. Dependent on arrangement and performance requirements draft losses can range from 4 to 10 in wg. This can be compensated with the addition of ID booster fans. If necessary, duct work, and /or boiler box reinforcement need to be considered. In conjunction with the fan modification, the upgrade of the auxiliary power system might be necessary. Auxiliary power modifications may also be necessary for ammonia supply system requirements.

4.3 PM Control Technologies

PM control technologies that were identified as available for retrofit at OPGC II are listed below:

- Existing ESP Enhancements
- Dual Flue Gas Conditioning
- New Pulse Jet Fabric Filter (PJFF)
- GE MAX 9 Hybrid
- Multi-cyclone
- Wet ESP
- Multi-Pollutant Removal Systems

Technology Considered –Dual Flue Gas Conditioning:

For most coal fired power boilers in India, the fly ash produced usually have high resistivity. There as on for the higher fly ash resistivity in low-sulfur fuels is the lower concentration of ionic sulfur oxides molecule in the flue gas that have high conductivity. This is not optimal for fly ash capture in an ESP and also limits the boiler fuel flexibility as the ESP design is based on a limited range of fly ash characteristics. To improve the capture of the particulate in the ESP and to overcome the limited range of fly ash applicability for capture in an ESP, the flue gas leaving the air heater into the ESP can be conditioned by the addition of ionic compounds such as sulfur trioxide and ammonia. Injecting a small amount of SO_3 into the flue gas prior to its entry into the ESP creates sulfuric acid ($SO_3 + H_2O \rightarrow H_2SO_4$).These compounds combine with the moisture in the flue gas and are deposited on the surface of the fly ash particles. This will increase the conductivity of the fly ash, therefore making it suitable to be captured (increasing the collection efficiency of the ESPs). Dual gas conditioning refers to injection of both SO_3 and ammonia independently. Ammonia improves attachment of SO_3, extends performance at higher temperatures and also reduces precipitator ash re-entrainment.

The equipment to produce SO_3 utilizes elemental sulfur as the feedstock. The sulfur is combusted to produce SO_2 gas at 5% concentration to air. The SO_2 gas is passed through a catalyst bed to convert the gas to SO_3 for the process. The hot SO_3 gas is injected into the duct upstream of the ESP

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through custom designed injection probes to evenly distribute the gas across all ash particles.

The NH_3 equipment utilizes anhydrous ammonia as the feed stock. The ammonia is vaporized and metered to the proper ratio of SO_3 and flue gas volume as required to condition the fly ash. The metered ammonia is diluted with air to a maximum of 5% concentration of NH_3 to air. This diluted mixture is injected into the duct upstream of the ESP through custom designed injection probes to evenly distribute the gas across the flue gas duct.

5.0 Cost Estimates

This section provides the AQC technologies capital and annualized operating costs.

The conceptual project cost is intended to allow an evaluation of the economic differences between the AQC technologies. The cost estimate includes major equipment costs, such as the auxiliary power system modifications, mechanical balance-of-plant equipment, ID or booster fans, draft system component and duct work stiffening and civil/ structural modifications. A project contingency factor was applied to the direct and indirect costs to account for other equipment not included in the estimate. The costs of engineering and home office fees, construction management, and construction indirect costs were also included. Owner's costs and an allowance for funds used during construction were also estimated. The total indicative capital cost is the sum of the purchased equipment cost, direct installation costs, indirect costs, contingencies, owner's costs, and allowance for funds used during construction.

Indicative capital costs for the Wet FGD, FGC system and SCR system were developed based on previous budgetary proposals, in-house estimates from past projects, equipment / material cost estimates, and internal Black & Veatch cost factors.

The indicative capital cost for the Wet FGD systems include the following features:

- Flue Gas Desulfurization Vessels and Associated Equipment.
- Reagent preparation system and byproduct dewatering system
- Waste water treatment system
- New stack with borosilicate glass lining for acid corrosion protection
- Flue Gas Duct work.
- Draft System Stiffening.
- Tanks, Pumps, and Inter connecting Piping.
- Bulk Material Handling Equipment for limestone and byproduct.
- New centrifugal ID fans, VFDs and supporting equipment.
- Auxiliary Transformers and Electrical equipment

Annual O&M costs for the Wet FGD technologies consist of the following cost categories:

- Operating labor costs.
- Maintenance materials and labor.
- Reagent.

- Byproduct disposal.
- Auxiliary power.
- ID or booster fan power costs.
- Service water costs.

The costs of reagent (limestone), byproduct disposal, and auxiliary power are variable annual costs that differ with the amount of SO_2 removed. Table5-1 represents the summary of cost estimates for the Wet FGD technology.

Table5-1 Summary of Cost Estimates for Wet FGD Technology

PARAMETERS	COSTS(INR
Purchased Equipment Cost	4,39,57,96,000
Installation Cost	1,91,73,69,000
Direct Cost	6,31,31,65,000
Indirect Cost	2,14,64,77,000
Allowance for Fund used During Construction	1,39,58,41,000
Total Installed Capital Costs	9,85,54,83,000
Fixed Annual Costs	8,26,32,000
Variable Annual Costs	93,64,10,000
Annualized O&M Costs	1,01,90,42,000
Capital Costs	9,85,54,83,000
Levelized Capital Costs	1,32,40,30,757
Levelized O&M Costs	1,69,99,30,818
Levelized Annual Costs	3,02,39,61,575
Life-Cycle Costs/Cumulative Present Value	90,71,88,47,237
Cost Effectiveness, INR/tons of SO_2 removed	34,544

Table 5-2 represents the summary of cost estimates for the SCR system.

Table5-2 Summary of Cost Estimates for SCR Systems

PARAMETERS	COSTS(INR
Purchased Equipment Cost	2,29,88,26,000
Installation Cost	71,37,42,000
Direct Cost	3,01,25,68,000
Indirect Cost	1,02,42,73,000
Allowance for Fund used During Construction	66,60,79,000
Total Installed Capital Costs	4,70,29,20,000
Fixed Annual Costs	3,76,26,000
Variable Annual Costs	45,89,43,000
Annualized O&M Costs	49,65,69,000
Capital Costs	4,70,29,20,000

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Levelized Capital Costs	63,18,11,828
Levelized O&M Costs	82,83,59,328
Levelized Annual Costs	1,46,01,71,156
Life-Cycle Costs /Cumulative Present Value	43,80,51,34,668
Cost Effectiveness, INR/tons of PM removed	61,255

Table5-3 represents the summary of cost estimates for the FGC system.

Table5-3 Summary of Cost Estimates for FGC System

PARAMETERS	COSTS(INR)
Purchased Equipment Cost	18,26,67,000
Installation Cost	6,74,27,000
Direct Cost	25,00,94,000
Indirect Cost	8,50,32,000
Allowance for Fund used During Construction	1,84,32,000
Total Installed Capital Costs	35,35,58,000
Fixed Annual Costs	40,01,000
Variable Annual Costs	2,53,40,000
Annualized O&M Costs	2,93,41,000
Capital Costs	35,35,58,000
Levelized Capital Costs	4,74,98,602
Levelized O&M Costs	4,89,45,647
Levelized Annual Costs	9,64,44,249
Life-Cycle Costs/Cumulative Present Value	2,89,33,27,479
Cost Effectiveness, INR/tons of PM removed	1,19,759

6.0 Conclusion

The Wet FGD system, FGC system along with SCR system is the most cost effective control technologies suited for units of OPGC II for meeting the Category3 limits.

For meeting SO_2 emission target, different technologies like Wet FGD, Ammonia based FGD, Semi-Dry FGD and Re ACT™ were considered, but only Wet FGD was found to be the most cost effective in meeting the category 3 limits i.e. 100mg/Nm^3.

For meeting NOx emission target, different technologies like SCR, Induct SCR, a new LNB with OFA, Re ACT™ and the different technically feasible combinations of aforementioned technologies were considered in meeting thecategory3 limits i.e. 100mg/Nm^3.

For meeting PM emission target, different technologies like FGC, ESP modification, ESP TR Set Replacement, MEEP, FF, and SD FGD were considered, but only FGC system was found to be the most cost effective in meeting the category3 limits i.e. 30mg/Nm^3. Also, OPGC does not want to perform any modification to the existing ESP and hence ESP modification, ESP TR replacement, and MEEP were not viable options.

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