中交产投巴基斯坦电力有限公司

CIHC PAK POWER COMPANY LIMITED

No. CIHC/POCPEC/2018-198

December 29, 2018

The Registrar,
National Electric Power Regulatory Authority,
NEPRA Tower, Ataturk Avenue-East G-5/1,
ISLAMABAD.

SUBJECT: **SUBMISSION OF MOTION FOR LEAVE FOR REVIEW OF 300 MW COAL FIRED POWER PROJECT AT GWADAR (PROJECT)**

Dear Sir,

We, CIHC Pak Power Company Limited, hereby submit our Motion for Leave for Review against the Decision of Authority in the Matter of Tariff Petition filed by the Company bearing reference No. NEPRA/TRF-434/CPPCL-2018/19549-19551 dated 19 December 2018.

Pursuant to Section 16 (6) of the National Electric Power Regulatory Authority (Tariff Standards and Procedure) Rules, 1998, a Motion for Leave for Review is required to be filed within ten (10) days of service of the determination, which in the present case is to expire on December 29, 2018.

Please acknowledge the same.

REGISTRAR
Dy. No: 12708
Dated: 31-12-18

Contact (**Syed/syedirfanrehman786@gmail.com/0304-1970029**)

For and on behalf of
CIHC Pak Power Company Limited

Xu Jun
Chief Executive Officer

— DRO I / Dy-I
For information & n/a pl.
Copy to:
— SA (Tech)
— SAT-I
— DG (M&E)
— AAG (Lic)
— LA (IPP) - MF
31.12.18
cc: chairman
m(T)/m(M&E)
m(CA) m(Lic)

VAKALATNAMA

CIHC Pak Power Company Limited (the "Petitioner"),

hereby appoint, authorize and constitute M/s Lincoln's Law Chamber through Barrister Asghar Khan Advocate and Faisal Atta Advocate, to appear, plead and act for us as our advocates in connection with the representation before NEPRA in the matter of the Motion for Review against the NEPRA Decision # Determination No. NEPRA/TRF-434/CPPCL-2018/19549-19551 dated 19th December, 2018 (the "**Impugned Decision**").

The Petitioner specifically authorizes the said Barrister / Advocate or any member of Lincoln's Law Chamber to do all acts and things necessary for the processing, completion and finalization of the Petition with NEPRA.

CIHC PAK POWER COMPANY LIMITED 中交产投巴基斯坦电力有限公司

中交产投巴基斯坦电力有限公司

CIHC PAK POWER COMPANY LIMITED

BEFORE
THE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY

MOTION FOR LEAVE FOR REVIEW

PURSUANT TO RULE 16(6) NEPRA (TARIFF STANDARDS AND PROCEDURE) RULES, 1998
READ WITH THE PROVISIONS OF
THE REGULATION FOR GENERATION, TRANSMISSION AND DISTRIBUTION OF ELECTRIC POWER ACT
(XL OF) 1997 & THE RULES AND REGULATIONS MADE THEREUNDER

ON BEHALF OF

CIHC PAK POWER COMPANY LIMITED

IN RELATION TO THE DETERMINATION OF NATIONAL ELECTRIC POWER REGULATORY AUTHORITY DATED DECEMBER 19, 2018 IN THE MATTER OF TARIFF PETITION FILED DATED JANUARY 12, 2018

DATED: 29 DECEMBER 2018

CIHC PAK POWER COMPANY LIMITED
ADDRESS : HOUSE NO. 6, STREET 11, SECTOR F-7/2, ISLAMABAD, PAKISTAN
EMAIL : cppcoffice@163.com
PHONE # : +92 310 2258888

中交产投巴基斯坦电力有限公司

CIHC PAK POWER COMPANY LIMITED

RESOLUTION BY CIRCULATION PASSED BY THE BOARD OF DIRECTORS OF CIHC PAK POWER COMPANY LIMITED

DATED 27th December, 2018

APPROVAL AND AUTHORIZATION TO FILE MOTION FOR REVIEW OF TARIFF APPLICATION FOR 300 COAL FIRED POWER PLANT AT GWADAR, BALUCHISTAN (PROJECT)

"Resolved that the Board of Directors be and hereby authorize the company to file Motion for Review of Tariff Petition including all supporting documents under, inter alia, NEPRA (Review Procedure) Regulations 2009, as amended and NEPRA (Tariff Standards and Procedure) Rules, 1998 (the "Motion for Review"), against the NEPRA Decision # Determination No. NEPRA/TRF-434/CPPCL-2018/19549-19551 dated 19th December, 2018 (the "**Impugned Decision**"), be and is hereby approved".

Further Resolved that the Chief Executive Officer of CIHC Pak Power Company Limited Mr. Xu Jun and Barrister Asghar Khan of M/s Lincoln's Law Chamber be and are hereby authorized for and on behalf of CIHC Pak Power Company Limited to sign all necessary documents, pay necessary fee, appear and file application s and pleadings before the Authority as needed and to do all such acts necessary for processing and completion of this Motion for Review and make such other representations which are required, be and is hereby approved".

For CIHC Pak Power Company Limited

CIHC PAK POWER COMPANY LIMITED 中交产投巴基斯坦电力有限公司

Signature _____

中交产投巴基斯坦电力有限公司

CIHC PAK POWER COMPANY LIMITED

AFFIDAVIT

BEFORE THE NATIONAL ELECTRIC POWER REGULA TORY AUTHORITY (NEPRA)

I, **Xu Jun**, duly authorized representative of **CIHC Pak Power Company Limited,** do hereby solemnly affirm and declare that the contents of the accompanying Motion for Review including all supporting documents under, inter alia, NEPRA (Review Procedure) Regulations 2009 as amended and NEPRA (Tariff Standards and Procedure) Rules, 1998 (the "Motion for Review"), against the NEPRA Decision # Determination No. NEPRA/TRF-434/CPPCL-2018/19549-19551 dated 19th December, 2018 (the "**Impugned Decision**") are true and correct to the best of my/our knowledge and belief and that nothing has been concealed.

I also affirm that all further documentation and information to be provided by me in connection with the accompanying Motion for Review shall be true to the best of my knowledge and belief.

DEPONENT

CIHC PAK POWER COMPANY LIMITED 中交产投巴基斯坦电力有限公司

Signature_____

Date: December 27, 2018

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1. DETAILS OF THE PETITIONER

NAME AND ADDRESS

CIHC Pak Power Company Limited
ADDRESS : HOUSE NO. 6, STREET 11, SECTOR F-7/2, ISLAMABAD, PAKISTAN
EMAIL : cppcoffice@163.com
PHONE NO. : +92 310 2258888

AUTHORIZED REPRESENTATIVE OF CIHC PAK POWER COMPANY LIMITED

NAME: XU JUN
DESIGNATION: CEO

2. GROUNDS FOR MOTION FOR LEAVE FOR REVIEW

2.1 CIHC Pak Power Company Limited (the **"Company"**), a private limited company incorporated under the laws of Pakistan, is establishing a Coal based Power Project at Gwadar, Balochistan with a capacity of 2 x 150 MW (the **"Project"**).

2.2 Following signing of the EPC contract, the Company filed an EPC-stage tariff Petition with National Electric Power Regulatory Authority (**"NEPRA"**) on 12 January, 2018 (**"Tariff Petition"**).

*(Tariff Petition attached herewith as **Annexure A**).*

2.3 NEPRA, in exercise of its powers under Section 7(3)(a) read with Section 31 of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997 (**"NEPRA Act"**), determined and approved the generation tariff for the Project, based on the information provided by the Company. NEPRA issued its Determination in the matter of Tariff Petition filed by the Company bearing reference No. NEPRA/TRF-434/CPPCL-2018/19549-19551 dated 19 December 2018 (the **"Impugned Order"**).

*(Impugned Order attached herewith as **Annexure B**).*

2.4 Pursuant to Rule 16(6) of the NEPRA (Tariff Standards and Procedure) Rules, 1998 (**"Tariff Standards and Procedure Rules"**) read with the provisions of the NEPRA Act and the Rules and Regulations made thereunder and for the grounds given below, the Company is filing this Motion for Leave for Review (**"Motion for Leave for Review"**), before NERPA, against certain provisions of the Impugned Order. We ask for NEPRA's review and reconsideration in respect of the same on account of the reasons discussed below.

2.5 Each of the grounds for the Motion for Leave for Review have been elaborated upon in the Sections below, and consist of the following heads:

(a) Adjustment on Account of Engineering, Procurement & Construction ("**EPC**") Cost;
(b) Adjustment on Account of additional cost items within EPC scope;
(c) Adjustment on Account of Custom Duties, Withholding Tax and Sales Tax;
(d) Adjustment on Account of Non-EPC cost;
(e) Adjustment on Account of Project Development Costs and Company Sponsor Costs;
(f) Adjustment on Account of Insurance during Construction;
(g) Adjustment on Account of O&M Mobilization Cost;
(h) Adjustment on Account of Non-reimbursable fuel and start-up charges;
(i) Adjustment on Account of Sinosure Fee;
(j) Adjustment on Account of Financing Fees & Charges;
(k) Adjustment on Account of Auxiliary Consumption;
(l) Adjustment on Account of Thermal Efficiency;
(m) Adjustment on Account of O&M Costs;
(n) Adjustment on Account of Debt to Equity Ratio;
(o) Adjustment on Account of Return on Equity;
(p) Adjustment on Account of Fuel Cost Component;
(q) Adjustment on Account of Insurance during Operations; and
(r) Payment mechanism for Capacity Payments.

2.6 We request that the Company be allowed subsequent to this filing and during the proceedings, to take additional grounds, submit additional evidence and make further submissions in relation to this Motion for Leave for Review.

2.7 Further, we would be pleased to provide any further information, clarification or explanation that may be required by NEPRA during the evaluation process.

3. ADJUSTMENT ON ACCOUNT OF EPC COST

3.1 Despite the Company's contention that the two projects are not comparable, the Authority has used EPC cost signed by Jamshoro coal-fired power project ("**JPCL**") as the benchmark for evaluating EPC cost of the Project. The Company has requested the Authority through various documents in the past that JPCL is not comparable to the Project with the underlying factors for such incomparability reiterated below:

a. A 150 MW unit project cannot be compared to a 660 MW unit project as there is a significant escalation in terms of per MW costs for the former over latter. Documents to support this have already been submitted to the Authority.
b. It is necessary to respectfully direct NEPRA's attention to their own reference to CERC benchmark prices provided in Article 10.8 of the Impugned Order where the per MW difference of costs between a 500 MW and 660 MW unit is in the range of 25%. Such a difference in case of a 660 MW and 150 MW would be significantly higher than the 25% applicable in case of 660/500 MW comparison.

c. However, the Authority has adopted the escalation of a 220 MW unit over 660 MW unit available in Upfront Tariff 2014 of 6% in the Impugned Order as the relevant escalation over JPCL EPC cost for the Project. This escalation is clearly not justified based on the contrary evidence already submitted to the Authority and the reference to CERC provided by the Authority itself in the Impugned Order.

*(Capital Cost Scaling Methodology attached herewith as **Annexure C**).*

d. JPCL is located in developed area with readily available infrastructure and having access to relatively cheaper inputs, services and manpower. Differences on this account have been highlighted to Authority.

e. JPCL is an extension of existing generation facility benefiting from synergies and cost-savings due to availability of existing site infrastructure.

f. JPCL is yet to file their tariff petition with the Authority nor has any information been made available to the Company to enable the Company to make an apple-to-apple comparison. This is of particular concern where majority of the costs related to civil works for the plant, residential colony etc. were parked in Non-EPC cost in the feasibility stage tariff petition by JPCL.

g. While determining the base cost for comparison purposes, the Authority has deducted from the EPC Cost of JPCL a capital cost of USD 62.04 million (USD 0.047 million per MW) on account of railway siding as the same is not in the scope of work for the Gwadar Project. As per our information the length of the railway siding is around 1 km and allocating a cost of USD 62.04 million (PKR 8,985 million) is totally unjustified as such costs are typically in the USD 0.6 million per km. This arbitrary allocation based on untenable assumptions may kindly be revisited.

3.2 The Authority has completely ignored the fact that the EPC cost has been arrived at through a transparent and competitive bidding process where any bidder was free to participate in the process including the ones who provided bids for larger sized projects.

3.3 In light of the above, it is humbly requested that either JPCL should not be used as a benchmark and the number arrived at through a transparent bidding process as per NEPRA Guidelines should be used to arrive at the EPC cost for the Project.

4. ADJUSTMENT ON ACCOUNT OF ADDITIONAL COST ITEMS WITHIN EPC SCOPE

4.1 Notwithstanding the below explanations, we would like to highlight that the specific items in Section 4 below were not a part of the Company's Tariff Petition but were explanations to account for differences between a standard project and the instant case.

4.2 ***Black Start Generator:*** The Authority has disapproved black start generator cost of USD 10.8 million on the premise that power requirements in case of complete shutdown can be met through local grid. The Authority should note that unlike other projects, the Project requires black start generator facility (approximately 14 MW) as the local grid is isolated, unreliable and

erratic and in case of a shut-down, plant will be restarted through self-generated power failing which it will be at risk of penalties. Considering the response rapidity and stability, a high speed diesel generator based black start solution has been recommended to meet the commitments required under the Power Purchase Agreement and Implementation agreement. Without the black start solution, in case of a shutdown, the Company cannot guarantee availability of the plant. Alternatively, in case the Authority feels that this requirement shall be met by QESCO, a direction should be issued and ensured under the terms of the PPA that in case of unavailability of power from QESCO, QESCO/CPPA-G shall be responsible for the loss of capacity payments to the Company and associated penalties under the PPA, if any, shall be waived. The Authority may further note that despite being located adjacent to one of the most developed cities of Pakistan (Karachi), 1,320 MW Port Qasim Electric Power Company were forced to shut down by the grid more than 10 times after COD.

4.2.1 ***Construction Power:*** The construction power cost of USD 12.5 million has been disapproved on the premise that local grid has notified to the Authority that power will be available to the Project most of the time. The Authority may kindly note that the Project site is served by a single, erratic 11 kV QESCO line. This power line terminus is not a reliable source for construction power based on general power supply situation in Gwadar town and adjoining areas. The erratic power supply could be just one of the many issues faced by Project. A typical 11 kV WAPDA/QESCO line may carry upto 5 MW, although WAPDA can tweak its 11 kV line to around upto 7 MW but at the serious risk of voltage drop and some other attendant problems. Therefore, it does not seem to be a sustainable and reliable option. The Project's peak requirement during construction phase is about 7 MW and a consistent steady load at 5-6 MW, and the total construction power consumption is around 30 million kWh. The Project's technical team and the EPC contractor are of the considered opinion that the existing QESCO resource available in the Project area poses unacceptable risk and hence needs remedy. Therefore, it is proposed that EPC Contractor bring generators to meet the power requirement during construction. The cost would include generator civil works, rental, maintenance, labour, fuel, installation, dismantling etc. of the generators. The fuel cost alone is expected to be in the range of PKR 33.0 per kWh (at December 2017 prices) as compared to a full tariff of PKR 13.20/kWh in case of projects being supplied construction power from the national grid. Hence, the incremental cost of construction power for the Project was estimated in the range USD 12.50 million.

4.3 ***Construction Water:*** While accepting the need for a desalination plant, the Authority has disallowed the rental, installation and dismantling of the desalination plant which may kindly be reconsidered. O&M cost alone is not sufficient to meet the cost of construction water. Furthermore, the Authority has allowed annual O&M cost of USD 0.341 million based on 5.69% of capital cost of desalination plant of USD 5.45 million, which based on 30-month construction period works out to be around USD 0.853 million. The Authority may kindly note that desalination plant is a highly corrosive equipment and requires extensive maintenance cost and fixing of the same based on 5.69% of capital cost seems unjustified. Since the EPC Contractor will bring in desalination plant to meet the water requirement during construction which shall include relevant civil works, plant rental, maintenance, operating cost, labour,

chemicals, installation, dismantling etc. of the desalination plant, the cost for the same may kindly be approved by the Authority.

4.4 ***Residential Colony:*** The Authority has reduced the residential colony cost based on the construction cost of PKR 5,000 per sq. ft. as opposed to PKR 5,700 communicated by the Company. The Authority may appreciate that basic construction costs of PKR 5,000 per sq. ft. cannot be compared with the cost for developing a full-fledged housing colony which will need to accommodate all kinds of amenities for the personnel which shall reside at the Project site. Moreover, current construction cost estimates may not hold for during the development/construction period of 3-4 years and reasonable margin on the same needs to be considered.

4.5 ***Anti-corrosion measures:*** The Authority has reduced anti-corrosion measures cost from USD 2.62 million to USD 1.30 million. The Project is located in a coastal area and needs to take into account anti-corrosive measures for its steel structure, foundation surface, enclosure material etc. Such measures include galvanizing, anti-corrosion coating and painting. The following breakup of total cost of anti-corrosion measures has already been provided to the Authority:

a. Anti-corrosion paint for steel structure at USD 1.15 million, based on estimated weight of 14,400 MT and unit price of USD 80 per MT.
b. Anti-corrosion coating for re-bars concrete foundation at USD 0.43 million, based on surface area of 85,000 m^2 and unit price of USD 5.05 per m^2.
c. Anti-corrosion paint to boiler steel frame and other equipment, pipe, supporting and hanger gallery at USD 1.04 million, based on estimated weight of 11,000 MT and unit price of USD 95 per MT, considering the higher unit price of equipment coating.

Therefore, the Company requests the Authority to evaluate the cost objectively.

4.6 ***Incremental Material Cost:*** The Authority has disallowed any incremental material cost on the premise that intercity prices published by Monthly Bulletin of Statistics does not provide any difference in Gwadar and Karachi prices. Whereas the list price of the specific item such as cement and steel may be the same, we understand that such prices do not take into account the transportation and handling costs of such material from the source to the Project site. It is not reasonable to assume that a material from Karachi will have the same price in both Karachi and Gwadar. As an illustration, the Company had provided quotes from D.G. Khan Cement, the nearest plant to the Project site. Material rates from an engineering firm and cement companies have been provided to Authority, which demonstrate additional costs in the range 15-35%. Based on the above, it is requested that based on material cost of 30-35% of on-shore cost of USD 120 million and incremental costs of around 30-35%, the costs explained by the Company may be allowed due to unavailability of these inputs at Gwadar and associated transportation costs.

4.7 ***Incremental Labour Cost:*** The Authority has not accepted the Company's contention about incremental labour cost by using the intercity prices published by Monthly Bulletin of Statistics, which provide incremental prices prevailing Gwadar of 28.58% over Karachi. The Company

genuinely doubts the reliability of the document as the quotes obtained by the Company from credible engineering firms show an a premium of 140-165% over rates in Karachi, documentation in which regard has been provided to the Authority. The Authority may note that the above document, even if relevant, would be for unskilled or low skilled labour and not for services being offered by qualified local and international engineers. We would therefore appreciate that the Authority may revisit its findings in this regard as per the evidence provided by the Company.

5. ADJUSTMENT ON ACCOUNT OF CUSTOM DUTIES, WITHHOLDING TAX AND SALES TAX

5.1 The Authority has not clarified whether non-adjustable sales tax will be included in the Project cost or will be allowed as a pass-through item to be recovered from CPPA-G. The Company would appreciate a clarification from the Authority in this regard.

6. ADJUSTMENT ON ACCOUNT OF NON-EPC COST

6.1 ***Satellite Communication System:*** The Authority has disapproved communication system cost of USD 1.64 million based on the premise that it is typically included in the EPC cost. It may be noted that this cost is unique to this Project where as there is no connectivity for communication and the Company will need to install communication towers, walkie talkie systems and will need to pay bandwidth fee and monthly fee to the communication operator. These costs are not typical to any project and hence should be allowed to the Project.

6.2 ***Training:*** The Authority has disapproved training cost of USD 2.33 million based on the premise that it is typically included in O&M mobilization. Training costs have been allowed as a separate cost component from O&M mobilization by the Authority in Bhikki and Balloki power projects and the Authority's decision is not in line with precedents. As a further explanation, the cost comprises training of 150 Pakistani engineers and technicians with annual college fees of USD 2,500 per person per year and travel cost of USD 2,000 per person. It also includes 6-month training in China for USD 1,000 per month per person including accommodation and practical experience. Such training is typically not provided by other projects and hence may kindly be allowed by the Authority in the instant case.

6.3 ***Vehicles:*** The Authority has disapproved vehicles cost of USD 0.90 million based on the premise that it is a pre-operation cost. The Authority should note that Project personnel will require extensive travelling during operations as well and the use is not limited to pre-operations phase.

7. ADJUSTMENT ON ACCOUNT OF PROJECT DEVELOPMENT COSTS AND COMPANY SPONSOR COSTS

7.1 The Authority has approved an amount of USD 7.73 million for project development, company and sponsor costs against the USD 47.87 million claimed by the Company. The Authority's basis for the same is the unsuccessful 330 MW Pind Dadan Khan Salt Range Power Project

where the EPC contractor was the project sponsor as well. Furthermore, it not reasonable to benchmark such costs against capex of 1,200 MW thermal projects as the absolute cost remains in the same range regardless of project size. Moreover, RLNG projects costs were based on local sponsor/employee costs, a package deal with NESPAK across three similar projects and locations far more developed than Gwadar.

7.2 Fearing Authority's use of inapplicable benchmarks, the Company in its correspondence had also requested the Authority to objectively evaluate each item under these heads objectively instead of using percentage benchmarks with other projects. The Authority has itself acknowledged in the past that these costs do not have a linear relationship with project size and hence comparison with other thermal projects with much larger size is not warranted.

7.3 In light of the above, it is requested that the Authority evaluates each item objectively and approve them accordingly.

8. ADJUSTMENT ON ACCOUNT OF INSURANCE DURING CONSTRUCTION

8.1 The Company applied for insurance during construction based on 1% of EPC cost which was in line with precedent determinations by the Authority for similar projects. However, the Authority has reduced the same based on Tariff Benchmark Guidelines vide SRO 763 (I)/2018 dated June 19, 2018 ("Guidelines") notified by the Authority, whereby the Guidelines have "proposed" insurance during construction for thermal projects at 0.75% of EPC cost and the same has been used by the Authority in the Impugned Order.

8.2 The Authority may kindly note that as per Article 1(2) of the Guidelines, the Guidelines shall come into force after three months from the date of notification of the Guidelines i.e. 19 September 2018. As per Article 2 of the Guidelines, the Guidelines shall be applicable to all applications for tariff determination under NEPRA Tariff Standards and Procedure Rules, 1998, and the NEPRA Up-front Tariff (Approval & Procedure) Regulations, 2011 filed after the coming into force of these guidelines i.e. 19 September 2018.

8.3 Since the Company submitted their application for tariff determination on 12 January 2018, well before the publication of the Guidelines, the benchmarks as per the Guidelines should not be used in the instant case and are inapplicable. The NEPRA Authority has misdirected itself by taking into account the benchmarks as laid down in the Guidelines.

9. ADJUSTMENT ON ACCOUNT OF O&M MOBILIZATION COST

9.1 The Company applied for an O&M mobilization cost of USD 6.49 million in the Tariff Petition. The Authority has reduced the same on the premise that O&M mobilization and training together range around 1% of EPC cost in case of thermal projects.

9.2 The Authority seems to be referring to the cost approved for RLNG projects in the Impugned Order whereby the Authority should note that O&M mobilization cost and training cost were determined separately for all RLNG projects and total cost for the same were around 1.12%, 1.26% and 1.39% for Haveli Bahadur Shah, Balloki and Bhikki, respectively, in contrast to the 1% of EPC cost specified by the Authority in the Impugned Order.

9.3 Moreover, it would be appropriate that the Authority evaluate O&M mobilization breakup provided to the Authority rather than basing its decisions on comparison of tariffs determined 4 times the size of the instant Project.

10. ADJUSTMENT ON ACCOUNT OF NON-REIMBURSABLE FUEL AND START-UP CHARGES

10.1 The Company under the Tariff Petition had sought USD 3.44 million for fuel and start-up charges; however, the Authority has capped the same at USD 2.74 million. We feel that being a cost of non-reimbursable nature, this should be reimbursed at actual rather than imposing a ceiling on the same.

11. ADJUSTMENT ON ACCOUNT OF SINOSURE FEE

11.1 The Authority has allowed a Sinosure fee of 0.60% of yearly outstanding principal and interest amount during construction and operation period against the 0.75% assumed by the Company in the Tariff Petition. For clarification, the proposal of 0.75% included withholding tax of 20%, resulting in net Sinosure fee of 0.60%, which we would appreciate is clarified by the Authority, that whether withholding tax will be allowed as a pass-through item or the tariff component will be adjusted accordingly.

12. ADJUSTMENT ON ACCOUNT OF FINANCING FEES & CHARGES

12.1 The Company applied for financing fees and charges based on 3% of total Project debt which was in line with precedent determinations by the Authority for similar projects. However, the Authority has reduced the same based on Tariff Benchmark Guidelines vide SRO 763 (I)/2018 dated June 19, 2018 ("**Guidelines**") notified by the Authority, whereby the Guidelines have "proposed" financing fees and charges for thermal projects at 2% of debt and the same has been used by the Authority in the Impugned Order.

12.2 The Authority may kindly note that as per Article 1(2) of the Guidelines, the Guidelines shall come into force after three months from the date of notification of the Guidelines i.e. 19 September 2018. As per Article 2 of the Guidelines, the Guidelines shall be applicable to all applications for tariff determination under NEPRA Tariff Standards and Procedure Rules, 1998, and the NEPRA Up-front Tariff (Approval & Procedure) Regulations, 2011 filed after the coming into force of these guidelines i.e. 19 September 2018.

12.3 Since the Company submitted their application for tariff determination on 12 January 2018, well before the publication of the Guidelines, the benchmarks as per the Guidelines should not be used in the instant case and are inapplicable. The NEPRA Authority has misdirected itself by taking into account the benchmarks as laid down in the Guidelines.

13. ADJUSTMENT ON ACCOUNT OF AUXILIARY CONSUMPTION

13.1 The Authority has approved auxiliary consumption as 8% for the Project, which result in Net output to 276 MW. The Authority shall note that the requirement is too strict and unreasonable for the coal-fired power plant of this unit size.

Generally, the auxiliary power consumption of similar size unit is at 9%~9.5% for PC boiler technology, which is based on many power plants in international domain. It is also consistent with the No. NEPRA/TRF-UTC/2013/7195-7197 "Decision of the Authority regarding Reconsideration Request filed by Government of Pakistan in the matter of Upfront Tariff for Coal Power Projects" for the similar capacity unit with the same technology.

13.2 The test conditions for auxiliary power consumption of the unit shall finally conform to relevant stipulations of Pakistan.

13.3 Referenced itemized list of major equipment included into the auxiliary power consumption test (for two units) are attached, which result in total 26.936 MW for two units.

*(Auxiliary Consumption Breakup attached herewith as **Annexure D**).*

13.4 According to the above data, calculated auxiliary power consumption rate is 8.98%, considering the possible little change of different manufacture in future, the guaranteed auxiliary power consumption rate of 9% is reasonable for 150MW capacity unit.

13.5 Based on the above, the Company humbly requests the Authority to reconsider the auxiliary consumption as 9% of Gross output.

14. ADJUSTMENT ON ACCOUNT OF THERMAL EFFICIENCY

14.1 The Authority has approved net thermal efficiency of 37.65% for the power plant, which is based on auxiliary consumption of 8% with the following data:

a. Gross Efficiency of boilers at RSC: 92.79%
b. Gross Efficiency of steam turbine at RSC: 44.78%
c. Gross Efficiency of generators at RSC: 98.5

14.2 The Authority may note that the requirement is too strict and unreasonable for the coal-fired power plant of this size class.

14.3 According to ASME standard, the net thermal efficiency of the whole plant should be calculated as following

$$\eta = \frac{P_{net}}{\dot{m} Q_{ar,net}}$$

Where

P_{net}: net output of two units, 273.132 kW

$\dot{m}$: consuming rate of fuel of two units, 32.872kg/s

$Q_{ar,\,net}$: net calorific value, 22459.4 kJ/kg

Thus, η = 37.00 % shall be applied.

14.4 Even if based on the same method that the Authority adopted with the data in R Clause, considering on feasible auxiliary consumption of 9%, the calculated net thermal efficiency of plant is 37.24%, due to the possible little difference of heat rate from different OEMs, the guaranteed net thermal efficiency of plant is recommended as 37%.

14.5 It is in line with NEPRA previous decisions for 220MW unit capacity power plants, for the unit capacity of 150MW power plants, the net efficiency of the project is fair and reasonable at 37%.

14.6 Basing on the above mentioned, the Company requests the Authority to please reconsider the adjusted net thermal efficiency of 37% for the project.

15. ADJUSTMENT ON ACCOUNT OF O&M COSTS

15.1 The Company submitted a total O&M tariff of PKR 0.9001 per kWh which includes several operator and non-operator costs such as O&M contractor fee, corporate overheads, security cost, ash disposal, desulphurization etc. The Company believes the aforesaid cost to be justified on following grounds:

a. This includes special security cost of USD 2.26 million per annum (PKR 0.1167 per kWh), which given the strategic nature of the Project and its location is fully justified and should be allowed as a pass through item. O&M tariff net of special security cost works out to be PKR 0.7834 per kWh.

b. The amount includes cost of ash disposal of USD 1.64 million per annum (PKR 0.0847 per kWh) as well. This information has already been shared with the Authority on 2 September 2018. O&M cost (net of security and ash disposal cost) works out to be around PKR 0.6987 per kWh.

c. The Project has adopted sea-water flue gas desulphurization ("SWFGD") process, breakup of which has not been provided separately by the O&M contractor due to which precise amount for the standalone process cannot be provided by the Company. In this regard, the Authority should rely on Upfront Tariff 2014, in which PKR 0.09 per kWh was provided for limestone cost. The Authority may kindly note that although the Project will not use limestone in the Project, the purpose of using limestone is not eliminated entirely and desulphurization process still needs to be performed, which has certain cost associated to it. Therefore, using desulphurization cost of PKR 0.09 per kWh, net O&M cost works out to be PKR 0.6087 per kWh.

15.2 Compared to the above the Authority has allowed an O&M cost of PKR 0.49/kWh whilst comparing it with a 220 MW project under Upfront Tariff 2014. Firstly, it may be noted that O&M cost for a 220 MW is not comparable to O&M cost of a 150 MW unit; a fact which has been acknowledged in the Upfront Tariff 2014 itself when awarding different O&M tariffs for different project sizes. Secondly, benchmark tariff is being used from the determination which was published around 4.5 years back where indexed values of the same have increased to around PKR 0.54 per kWh @ PKR 105/USD.

15.3 Based on the indexed values, net O&M cost of PKR 0.6087 per kWh is only 12.7% higher compared to indexed O&M tariff of Upfront Tariff 2014, which stands justified on grounds of substantial escalator in terms of manpower and services cost which prevail in Gwadar compared to other similar projects developed in Pakistan.

16. ADJUSTMENT ON ACCOUNT OF DEBT TO EQUITY RATIO

16.1 As per Article 19.3 of the Impugned Order, the Authority has proposed that once proposed by the project company, change in capital structure resulting in higher tariff shall not be allowed. The Company proposed in the Tariff Petition that project will be funded by 80% debt based on indicative term sheet provided by lenders, which is pending final approval based on final tariff to be determined by the Authority. Capital structure typically determined by the Authority in the past allowed debt within the range of 70% -80% and even the Guidelines have not provided any change in this regard. In light of the same, the Authority may kindly retain the flexibility in debt to equity ratio as per the precedent.

17. ADJUSTMENT ON ACCOUNT OF RETURN ON EQUITY

17.1 The Authority has unilaterally reduced Return on Equity ("ROE") from 17% to 14% on the following basis:

a. Overall country risk has come down;
b. The need for power projects has reduced over time.

17.2 The Authority may note that country risk of a country is depicted by its macro-economic indicators such as foreign exchange reserves, current account balance, reserves adequacy, GDP growth etc. all of which are trending negatively since 2014. Mere addition of power to the grid does not itself bring down the overall country risk.

17.3 A brief summary of the overall country risk position is provided below:

a. Total debt and liabilities have increased from PKR 17.4 trillion in 2014 to PKR 28.4 trillion in 2018, an increase of 63.2%. The increase in the same as % of GDP is from 69% to 83% over the same period.
b. Current account deficit has increased from USD 3.13 billion in 2014 to USD 18.13 billion in 2018, an increase of 479%. The increase in the same as % of GDP is from -1.3% to -5.8% over the same period.
c. Foreign exchange reserves have reduced from USD 13.5 billion in 2015 to USD 9.89 billion in 2018, a decrease of 26.7%.
d. Credit rating at the start of 2015 by Fitch and Moody's was B and B3 respectively, which is considered a highly speculative country to invest in. The credit rating provided by Fitch and Moody's recently is B- and B3 respectively, which still falls under highly speculative category for investment.

17.4 Moreover, the Project is situated in a high risk zone as well as the CSR requirements imposed on the Company further justify the need for a higher return.

17.5 In light of the above, we feel that the Authority may kindly reconsider its decision on the matter and approve the return sought by the Company of 17%.

18. ADJUSTMENT ON ACCOUNT OF FUEL COST COMPONENT

18.1 As per Article 22.4 of the Impugned Order, the Authority has set the fuel pricing mechanism dated 23 September 2016 ("**Fuel Pricing Mechanism**") as the governing document for pricing coal. The Authority should note that Fuel Pricing Mechanism has only set API-4 as the relevant index to be used for South-African coal regardless of the calorific value of the same. Therefore, until and unless the Fuel Pricing Mechanism is not adjusted and a revised mechanism is not

published by the Authority, any partial revision without any decision by the Authority may not be imposed on the Project.

18.2 Moreover, as per Article 22.3 of the Impugned Order, the Authority has changed the benchmark index for coal price from API-4 to API-3 on the premise that the design coal requirements for the Project is 5,500 kCal/kg. The Authority may note that as per the performance guarantees submitted to the Authority, the design coal calorific value is 5,371 kCal/kg (LHV) on as received basis, which is basically the minimum calorific value required to ensure performance of the boiler. Therefore, calorific value of coal used may be beyond 5,500 kCal/kg during operations upon which API-4 will be the relevant index. Therefore, it is proposed that the relevant index may be kept flexible based on which calorific value coal will be procured by the Company.

19. ADJUSTMENT ON ACCOUNT OF INSURANCE DURING OPERATIONS

19.1 The Company applied for insurance during operations based on 1% of EPC cost which was in line with precedent determinations by the Authority for similar projects. However, the Authority has reduced the same based on Tariff Benchmark Guidelines vide SRO 763 (I)/2018 dated June 19, 2018 ("**Guidelines**") notified by the Authority, whereby the Guidelines have "proposed" insurance during operations for thermal projects at 0.70% of EPC cost and the same has been used by the Authority in the Impugned Order.

19.2 The Authority may kindly note that as per Article 1(2) of the Guidelines, the Guidelines shall come into force after three months from the date of notification of the Guidelines i.e. 19 September 2018. As per Article 2 of the Guidelines, the Guidelines shall be applicable to all applications for tariff determination under NEPRA Tariff Standards and Procedure Rules, 1998, and the NEPRA Up-front Tariff (Approval & Procedure) Regulations, 2011 filed after the coming into force of these guidelines i.e. 19 September 2018.

19.3 Since the Company submitted their application for tariff determination on 12 January 2018, well before the publication of the Guidelines, the benchmarks as per the Guidelines should not be used in the instant case and are inapplicable. The NEPRA Authority has misdirected itself by taking into account the benchmarks as laid down in the Guidelines.

20. PAYMENT MECHANISM FOR CAPACITY PAYMENTS

20.1 The Authority erred while prescribing that any delay on the part of the Power Purchaser / NTDC to complete the interconnection works shall result in 'Take and Pay' arrangement. This means that although the plant is ready for commissioning and operations, it cannot provide electricity to the national grid due to non-availability of the interconnection arrangement.

20.2 Furthermore, even though the delay is caused by and on account of the Power Purchaser / NTDC, the Company will be penalized in not getting the payments and shall therefore default on the payments to the lenders and contractors whereas the Power Purchaser / NTDC will get away without any penalty. They shall have no incentive or an obligation to complete the interconnection works in time as there are no penal consequences attached with it.

20.3 This new proposal and term and condition of the Tariff is unprecedented and contrary to the terms and conditions of the Power Purchase Agreements approved by the Government of Pakistan since 1994 and in breach of the Power Generation Policy 2015 wherein the

responsibility of providing timely interconnection works lies with the Power Purchaser / NTDC. Moreover, in project financing, the risk and cost of a particular cause or event is borne by a party that can best handle or manage it which in this particular case for interconnection works is Power Purchaser / NTDC.

20.4 It is therefore submitted that this condition is deleted and same terms and conditions are made applicable that were given to other power projects.

21. PRAYER

In view of the above, it is hereby most respectfully requested that NEPRA may kindly be pleased to:

(i) Accept this Motion for Review; and

(ii) Review and Reconsider the Impugned Order dated 19 December 2018.

FOR AND ON BEHALF OF
CIHC PAK POWER COMPANY LIMITED

.....

Xu Jun
CEO

CIHC PAK POWER COMPANY LIMITED 中交产投巴基斯坦电力有限公司

附件2：电价申请文件

Annex A

BEFORE

THE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY

AMENDED AND RESTATED TARIFF PETITION

ON BEHALF OF

CIHC PAK POWER COMPANY LIMITED ("CPPCL")

FOR NEPRA'S APPROVAL OF REFERENCE GENERATION TARIFF FOR CPPCL'S 300 MW COAL-FIRED POWER PLANT TO BE SETUP

AT

GWADAR, BALOCHISTAN

DATED: JANUARY 12, 2018

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LIST OF ACRONYMS

BOO	Build, Own, Operate
CAPEX	Capital Expenditure
CIHC	CCCC Investment Holding Company Limited
CIF	Cost, Insurance and Freight
COD	Commercial Operations Date
CPEC	China Pakistan Economic Corridor
CPI	Consumer Price Index
CPPA-G	Central Power Purchase Agency (Guarantee) Limited
CV	Calorific Value
EIA	Environmental Impact Assessment
ENR	Engineering News-Record
EPC	Engineering, Procurement and Construction
FOB	Free on Board
GDA	Gwadar Development Authority
GoB	Government of Balochistan
GoP	Government of Pakistan
Hrs	Hours
IDC	Interest during Construction
IRR	Internal Rate of Return
JCC	Joint Cooperation Committee for CPEC
Kcal/kg	Kilocalories per kilogram
KIBOR	Karachi Interbank Offered Rate
Km	Kilometres
kV	Kilovolts
kWh	Kilowatt Hours
LIBOR	London Interbank Offered Rate
LOI	Letter of Intent
LOS	Letter of Support
MOU	Memorandum of Understanding
MT	Metric Tons
MW	Megawatts
MWh	Megawatt Hours
NAR	Net as Received
NEPRA	National Electric Power Regulatory Authority
NEPRA Act	Regulation for Generation, Transmission and Distribution of Electric Power Act (XL of) 1997
NEPRA Rules	NEPRA Tariff Standards and Procedure Rules, 1998
NO_x	Nitrogen Oxide
NTDC	National Transmission and Despatch Company Limited
O&M	Operations and Maintenance
OBOR	One Belt, One Road
PKR	Pakistan Rupees
PPA	Power Purchase Agreement
PPIB	Private Power and Infrastructure Board
RFP	Request for Proposal

ROE	Return on Equity
SCR	Selective Catalytic Reduction
SO_x	Sulphur Oxide
USD	United States Dollar

1. Details of Petitioner

Name and Address

CIHC Pak Power Company Limited ("**CPPCL**" or "**Project Company**")
House No. 6, Street No. 11,
Sector F-7/2,
Islamabad, Pakistan.

Authorized Representative of CPPCL

Mr. Xu Jun
Chief Executive Officer

2. Background & Regulatory Framework

2.1. Project Background

In May 2013, the Chinese Premier, Li Keqiang visited Pakistan and proposed joint development projects focusing on energy, infrastructure and agriculture later put forth as China Pakistan Economic Corridor ("**CPEC**"). Gwadar's deep-water port and its surrounding areas have become a major part of this economic development initiative. The port at Gwadar, Balochistan, is to act as the southern-most terminating point of the greater One Belt, One Road ("**OBOR**") initiative and also to serve as its sole marine outlet. Accordingly, significant increase in industrial, commercial and residential electrical load at Gwadar is expected as OBOR matures.

Currently, Gwadar depends on approximately 70 MW of electric power imported from Iran. Of this, approximately 14 MW is allocated to Gwadar, while the Makran Coastal region utilizes the remaining 56 MW. Moreover, there is no interconnection point in or close to Gwadar with the national grid. Instead, there is a relatively independent, localized, grid that connects Gwadar, Turbat, Panjgur and Pasni. The limited power supply coupled with an inefficient distribution system results in daily outages of 12 to 16 hours.

Keeping in view the strategic importance of Gwadar to CPEC and the anticipated rapid growth thereof, the Joint Cooperation Committee for CPEC (the "**JCC**"), decided in its sixth (6th) meeting, held in Beijing in December 2016, that a 300 MW imported coal fired power project (the "**Project**") must be developed on fast track basis at Gwadar. The Project is intended to not only meet the current demand for power in Gwadar and adjoining areas, but will also support future demand growth. The JCC nominated China Communications Construction Company ("**CCCC**"), a subsidiary of China Communications Construction Group ("**CCCG**"), or its nominated subsidiary to undertake this development on an expedited basis. In the 7th Meeting of the JCC held on November 21, 2017 it was decided that the Sponsor of the Project shall be CCCC Industrial Investment Holding Company Limited ("**CIHC**" or "**Sponsor**"), another subsidiary of CCCG. The Sponsor has incorporated CPPCL as the special purpose company to develop the Project under and in accordance with the requirements of the Power Generation Policy 2015 of the Federal Government ("**Power Policy**") and NEPRA Licensing (Generation) Rules, 2000 ("**Generation Licensing Rules**").

2.2. NEPRA Act & NEPRA Rules

Under the Regulation for Generation, Transmission and Distribution of Electric Power Act (XL of) 1997 (the "**NEPRA Act**"), the National Electric Power Regulatory Authority ("**NEPRA**") is responsible, inter alia, for determining tariffs and other terms and conditions for the supply of

electric power services through generation, transmission and distribution activities. NEPRA is also responsible for determining the process and procedures for reviewing tariffs and recommending tariff adjustments. Further, pursuant to the enabling provisions of the NEPRA Act, the procedure for tariff determination has been prescribed in the NEPRA Tariff Standards and Procedure Rules, 1998 (the "**NEPRA Rules**"). Furthermore, the generation activities of the power producers are regulated through Generation License issued under Generation Licensing Rules.

2.3. Letter of Intent

As per the provisions of the Power Policy, the Sponsor filed a Letter of Intent ("**LOI**") application with Private Power and Infrastructure Board ("**PPIB**") and were issued a Notice to Proceed on April 12, 2017 (**Annex C**) followed by the LOI on May 26, 2017 (**Annex D**). As per the terms of the LOI, Sponsor are required to submit, within three (3) months from the date of the Notice to Proceed, petitions before NEPRA to obtain tariff determination and generation license under the NEPRA Act. The Sponsor filed the same on July 12, 2017 (**Annex E**) of which the tariff petition was admitted by NEPRA on August 28, 2017 (**Annex F**).

2.4. Project Chronology

i. In May 2013, a Memorandum of Understanding ("**MOU**") was signed between the Chinese and Pakistani Governments for the joint development of projects focusing on energy, infrastructure and agriculture which later came to be known as China Pakistan Economic Corridor.

ii. In November 2014, an Agreement on the China-Pakistan Economic Corridor Energy Project Cooperation between the Government of the People's Republic of China and the Government of the Islamic Republic of Pakistan was signed.

iii. In its sixth (6th) meeting, in December 2016, the Joint Cooperation Committee for CPEC nominated CCCC or its nominated subsidiary to undertake the development of 300 MW coal fired power project at Gwadar on an expedited basis.

iv. For the purpose, the Government of Balochistan ("**GoB**"), identified potential project sites to the Company. Based on that, the Sponsor conducted an initial site visit in January 2017 and identified three (3) potential project sites.

v. Following the site visits, CCCC filed a proposal on March 22, 2017 with PPIB for the issuance of a LOI.

vi. The Power Purchaser, CPPA-G, vide its letter dated April 10, 2017, communicated its consent to purchase power ("**Consent**") from the Project (**Annex G**).

vii. Following the Consent, PPIB on April 12, 2017, issued a Notice to Proceed for the Project to CCCC (**Annex C**) which was followed by an LOI, on May 26, 2017 (**Annex D**).

viii. On May 18, 2017, CCCC/CIHC confirmed its Project Site preference to the Gwadar Development Authority ("**GDA**"), which was acknowledged by GDA through its letter dated May 24, 2017 (**Annex H**).

ix. Subsequent to the Notice to Proceed, the CCCC commenced activities related to preparing a bankable feasibility study for the Project including site technical studies and an Environmental Impact Assessment ("**EIA**"). The Sponsor engaged the services of Hebei Electric Power Design & Research Institute for conducting the feasibility study for the Project.

x. Following detailed site surveys, the CCCC/CIHC identified an area approximately 207 acres for the construction of the Project at one of the potential sites. Initial

site investigations were undertaken and the results of the same have been incorporated in the feasibility study.

xi. Based on the requirements of the LOI, CCCC were obligated to submit a tariff application to NEPRA within three (3) months from the Notice to Proceed i.e. April 12, 2017.

xii. Given that the Upfront Tariff determined by NEPRA dated June 26, 2014 had ceased to exist, the CCCC were required to file a cost-plus tariff petition for the Project. CCCC filed the same and the generation license application on July 12, 2017.

xiii. NEPRA vide its letter dated August 28, 2017 reviewed the tariff petition (**Annex F**), and required CCCC to provide additional information following an EPC bidding process for further processing of the petition.

xiv. For the purposes of a cost-plus tariff petition, NEPRA through SRO 350(I)/2017 dated May 19, 2017, has notified the NEPRA (Selection of Engineering, Procurement and Construction (EPC) Contractor by Independent Power Producers) Guidelines, 2017 ("**EPC Selection Guidelines**") laying down the procedure and process for the determination of an EPC price through a competitive bidding process.

xv. The Project Company initiated the bidding process through publication of an advertisement on July 21, 2017 and subsequently a Request for Proposal ("**RFP**") was provided to potential bidders.

xvi. Bids were received from four (4) bidders on October 17, 2017. Technical bids were opened on the same day, whereas following an evaluation of the technical bids, the financial bids were opened on October 29, 2017.

xvii. Bids were received from Power China, Dongfang Electric, Shanghai Electric, and a Joint Venture ("**JV**") of China Harbour Engineering Company Limited ("**CHEC**") with China Energy Engineering Group Guangdong Electric Power Design Institute Co. Ltd ("**GEDI**").

xviii. Technical and financial bid evaluation was conducted by Zeeruk International (Private) Limited and an evaluation report for the same was completed on November 4, 2017.

xix. Based on the results of the evaluation report, the Project Company entered into negotiations with the highest evaluated bidder i.e. JV of CHEC and GEDI.

xx. Following negotiations, the Project Company has finalized the contracts for engineering, procurement and construction services for the Project with the JV of CHEC and GEDI.

xxi. As per the provisions of the Baluchistan Land Acquisition Act of 1894 ("**LAA**"), the Government of Balochistan has initiated proceedings under Section 4 of the LAA, for acquisition of 207 acres of land for the Project. On November 10, 2017 the Project Company received the final demand letter from Deputy Commissioner, Gwadar / Land Collector for payment of provisionally assessed land acquisition cost, expenses and charges. For this purpose, a Land Acquisition Agreement under Section 41 of the LAA between the Government of Balochistan and the Project Company is pending approval with the Government of Baluchistan.

xxii. Sponsors have engaged a consultant to conduct the Grid Interconnection study ("**GIS**") of the Project. A request for sharing of data for the study was sent by CPPA-G to NTDC on October 17, 2017, however, no technical data has been

received to date. We understand that the same is pending due to board approval of NTDC.

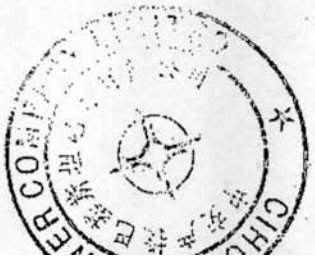
xxiii. As per the 7th JCC Meeting held on November 21, 2017, it was decided that the Project will be undertaken by CIHC, a subsidiary of CCCG, as the Main Sponsor and Initial Shareholder. Necessary approvals for the change are in process at the end of the Government of Pakistan / PPIB.

2.5. Submission

Pursuant to the relevant provisions of the NEPRA Act and in accordance with the Power Policy, the Project Company/Sponsor hereby submit herewith to NEPRA, for its determination, an amended and restated tariff petition (the "**Tariff Petition**") for approval of the reference generation tariff (the "**Reference Generation Tariff**") for the 300 MW (Gross) coal-fired power generation facility to be located at Gwadar, Balochistan. **This Tariff Petition supersedes the earlier tariff petition submitted by CCCC on July 12, 2017 (Annex E).**

The tariff to be determined by the Authority ("**Tariff Determination**") will be incorporated in the Power Purchase Agreement ("**PPA**") to be entered between the Company and Central Power Purchasing Authority (Guarantee) Limited ("**CPPA-G**" or "**Power Purchaser**").

All requisite information required by NEPRA for processing the Tariff Petition has been annexed herewith; CPPCL will be pleased to submit any further information as and when required by NEPRA in connection with the determination.



3. Key Features of the Project

Project Sponsor	CCCC Industrial Investment Holding Company Limited
Project Company	CIHC Pak Power Company Limited
Power Purchaser	Central Power Purchasing Agency (Guarantee) Limited
EPC Contractor	JV of CHEC and GEDI
Project Size	300.0 MW (Gross) (Mean Site Conditions) 273.1 MW (Net) (Mean Site Conditions)
Auxiliary Consumption	8.98%
Project Configuration	2x150.0 MW (Gross at Mean Site Conditions) 2x136.5 MW (Net at Mean Site Conditions)
Project Site	Gwadar, Balochistan, 40 km from Gwadar Port
Interconnection	132/220 kV
Fuel	Imported Coal
Construction Period	30 months from Financial Close
Net Efficiency	37% (Mean Site Conditions)
Annual Availability	85%
Annual Generation	2,033 GWh
Annual Fuel Consumed	~859,669 MT (Coal CV (NAR): 5,500 kCal/kg)
EPC Cost[1]	USD 369.89 million
EPC Cost[2]	USD 410.00 million
Project Cost[1]	USD 498.22 million
Project Cost[2]	USD 542.36 million
Capital Structure	80% Debt and 20% Equity
Levelized Reference Tariff[1]	US cents 8.2513 per kWh
Levelized Reference Tariff[2]	US Cents 8.4935 per kWh

[1]Excluding Government Duties and Taxes
[2]Including Government Duties and Taxes

3.1 Project Description

3.1.1 Technology

The Project entails setting-up the Project on a build, own, operate ("**BOO**") basis based on imported coal. The Project is proposed to have two (2) units of 150 MW (gross) consisting of two (2) super-high-pressure boilers, two (2) steam turbines and two (2) generators. The boilers will be fired by pulverized coal imported from South Africa or other sources through Gwadar Port. From the Port, the coal will be trucked to the coal yards inside the complex. The Project will draw water from the Arabian Sea for cooling and other industrial and domestic uses as the site has no other water resource. Onsite desalination facilities will be provided to produce potable water, etc.

The site will have enough land for ash disposal for the life of the PPA. Onsite coal storage shall be able to store enough coal for 60 days at 100% capacity.

The complex shall be provided with black-start facilities enabling it to start on its own in the absence of grid power. The complex shall have effluent treatment facilities in order to minimize such discharges into the environment.

During construction, at peak times, site will have enough facilities for approximately 1,000 personnel in addition to infrastructure for the security team. The site shall have residential facilities for resident labour and management during the operations phase. It will also cater for temporary labour required to man annual and major outages. Given the security situation, the complex shall have accommodations for security personnel also.

Security infrastructure shall include boundary wall, topped by security fence, watchtowers, patrol road, security cameras and depending upon the security assessment, drone surveillance may also be considered. However, all such facilities shall be strictly in line with Pakistani laws and policies.

3.1.2 Environment

The project design, technology and equipment selection has been made with the intention to make the Project safe and environmentally compliant to all local laws and conventions.

SO_x shall be scrubbed by the outgoing seawater i.e. seawater desulfurization. The Project intends to use Selective Catalytic Reduction to further reduce the release of NO_x into the air.

3.1.3 Human Resources

The Project Company intends to indigenize project management and operations as quickly as possible. In order to achieve this goal, an extensive and effective training program, including training in China, will be offered to eligible local youth to become part of the project team.

3.2 Project Site

The Project is located at Gwadar, on the Arabian Sea coast, in the Southwest part of Balochistan, Pakistan. The Project will be located within the jurisdiction of the GDA, near the Surbundar area and will require 207 acres of land, to be acquired from and through the GoB. CCCC conducted a site survey in January 2017 and based on the findings of the survey, three (3) sites were chosen as site alternatives. The Project Site, was ultimately chosen as the recommended site on May 18, 2017.

The Site is mostly flat land, unsuitable for farming with sparse settlements nearby. The N-10 National Highway is to the north; the highway can connect to the Port and will become the main access. A port expressway has been planned for the east bay of the Port which will connect to the N-10. The Port lies to the southwest of the Project Site. The Project envisages using the existing jetty at the Gwadar Port and port infrastructure therein for coal receival from ocean going vessels bringing coal from South Africa and loading the coal onto trucks.

3.3 Interconnection

The complex is proposed to be connected with the 132kV infrastructure, with two loops of outgoing lines, to be built by NTDC. Interconnection point shall be the outgoing gantry of the switchyard after stepping it up to 132kV. A Grid Interconnection Connection Study (**"GIS"**) is being undertaken by the Project Company in consultation and coordination with NTDCL.

3.4 Sponsor Introduction

3.4.1 CCCC Industrial Investment Holding Company Limited ("CIHC")

CIHC will be the main sponsor and the majority shareholder of the Project Company. CIHC is a wholly owned subsidiary of China Communications & Construction Group (**"CCCG"**). CCCG was formed in December 2005 as a result of a merger between China Harbour Engineering (Group) Company (**"CHEGC"**) and China Road and Bridge Corporation (**"CRBC"**). CCCG is

supervised by the State-Owned Assets Supervision and Administration Commission of the State Council.

CCCG had a consolidated annual turnover of over USD 65 billion and a consolidated asset base of over USD 140 billion in 2015. It has 12 affiliates with over 100,000 employees involved in various lines of businesses. CCCG through its affiliates is involved in general contracting of construction of ships, domestic and overseas port, channel, road and bridge construction projects (including engineering technical economic consultation, feasibility research, reconnaissance, design, construction, supervision, procurement and supply of relevant complete equipment and materials, and equipment installation), industrial and civil engineering, railway, metallurgy, petrochemical, tunnel, electric, mine, hydraulic and municipal construction. Other businesses include, but not limited to, import and export business, real estate development and management, investment and management in the sectors of transport, hotel, and tourism. Following is a list of the affiliates:

- China Communications Construction Company Limited
- Southwest Municipal Engineering Design and Research Institute of China
- CCCG Real Estate Group Co., Ltd
- CCCC Xingyu Science and Technology Co., Ltd
- CCCC Industrial Investment Holding Company Limited
- CCCC Pakistan Investment Co. Ltd
- Northeast Municipal Engineering Design and Research Institute of China
- CCCC Gas Heat Research and Design Institute Co., Ltd
- CCCC Chenzhou Road Machinery Plant
- Guangzhou Port Machinery Industrial Corporation
- China Road and Bridge (Hong Kong) Co., Ltd
- Communications Construction News Co., Ltd

4. Proposed Tariff and Indexations

4.1 A two-part tariff structure based on energy and capacity payments is proposed in accordance with Clause 10 of the Power Policy. Capacity payments shall be payable by the Power Purchaser based on availability of the Plant whereas energy payments shall be billed and be payable based on the net electrical output of the Plant.

4.2 The proposed tariff for the Project is summarized as follows:

Component	Year 1 to 12.5	Year 12.5 to 30
Fuel Cost Component	4.5196	4.5196
Variable O&M (Foreign)	0.0662	0.0662
Variable O&M (Local)	0.0717	0.0717
Energy Purchase Price (Rs./kWh)	**4.6574**	**4.6574**
Fixed O&M (Foreign)	0.4276	0.4276
Fixed O&M (Local)	0.2203	0.2203
Insurance	0.1624	0.1624
SINOSURE Fee (Average)	0.1144	0.0357
Cost of Working Capital	0.1483	0.1483
Return on Equity during Construction	0.1961	0.1961
Return on Equity	0.8095	0.8095
Debt Servicing	2.1017	0.0000
Capacity Purchase Price (Rs./kW/hr)	**4.1804**	**2.0000**
Capacity Purchase Price (Rs./kWh)	**4.9181**	**2.3529**
Total Tariff (Rs./kWh)	**9.5755**	**7.0103**
Levelized (Rs./kWh)		**8.9182**
Levelized (US cents/kWh)		**8.4935**

4.3 The following indexations will be applicable for the proposed tariff:

Component	Applicable Indexation
Fuel Cost Component	Delivered Fuel Price as per formula determined by NEPRA
Variable O&M (Foreign)	PKR/USD Rate and US CPI
Variable O&M (Local)	Pakistan CPI
Fixed O&M (Foreign)	PKR/USD Rate and US CPI
Fixed O&M (Local)	Pakistan CPI
Insurance	PKR/USD Rate on 1st day of each agreement year
SINOSURE Fee	PKR/USD Rate and 3M LIBOR
Cost of Working Capital	3M KIBOR and landed coal price
Return on Equity during Construction	PKR/USD Rate
Return on Equity	PKR/USD Rate
Principal Repayment	PKR/USD Rate
Interest Payments	3M LIBOR and PKR/USD Rate

4.4 Reference Dates and Rates

The following reference dates/rates have been assumed with respect to the above indexations. EPC bidding date/month has been considered the relevant base for reference dates/rates.

Exchange Rate (PKR/USD)	105.00
3-Month KIBOR	6.53%
3-Month LIBOR	1.37%
US CPI	246.66
Pakistan CPI	219.61
FOB Coal Price Richards Bay (USD/MT) (NAR 5,500kcal/kg)	83.41

5. Key Factors Underlying the Calculations of the Proposed Tariff

5.1 Project Cost Assumptions

Following is the proposed capital cost of the Project:

Particulars	USD Million
EPC Cost	369.89
Custom Duties, Withholding and Sales Tax	40.11
Non-EPC Costs	10.64
Land	5.00
Project Development Costs	21.03
Company and Sponsor Costs	26.84
Insurance during Construction	3.70
O&M Mobilization	6.49
Non-reimbursable Fuel and Start-up Cost prior to synchronization	3.44
SINOSURE Fee during Construction	9.21
Financing Fees and Charges	13.12
Interest during Construction (IDC)	32.90
Total Project Cost	**542.36**

5.1.1 EPC Cost

The Engineering, Procurement & Construction ("EPC") Cost includes costs of procurement, engineering design, site preparation, construction of boundary wall, access road, bridge on river/creek, temporary facilities, main plant (incl. import, installation, erection, completion, commissioning of boiler, turbine and generator), balance of plant (electrical and mechanical equipment and systems), control and metering, civil works, coal handling system, ash handling system, on-site ash disposal system, seawater intake and outfall channels, black start generator, desalination plant, electrostatic precipitator, selective catalytic reduction ("SCR") to capture NO_x, colony, project management, erection and commissioning, security costs and security personnel accommodation.

5.1.1.1 EPC Bidding Process ("Bidding Process")

EPC Selection Guidelines prescribe the procedure and process for the determination for an EPC price through a competitive bidding process. A chronology of events in this regard is as follows:

- On July 2017, the Bidding process was initiated by the Project Company/Sponsors through publication of an advertisement (**Annex I**). The advertisements were published in local newspapers Dawn, Business Recorder, The News and Express Tribune; international newspapers People's Daily and Reference News; as well as the tendering websites Global Tenders and Powertender.
- A total of thirteen (13) companies/JVs purchased the prequalification documents and following nine (9) submitted the prequalification documents:
  - JV of CHEC and GEDI,
  - Shanghai Electric,
  - Dongfang Electric,
  - Power China,
  - China National Electric Engineering Co., Ltd,
  - Consortium of China Gezhouba Group International Engineering Co. Ltd,
  - Consortium of Northeast Electric Power Design Institute Co. Ltd,
  - China Huadian Engineering Co. Ltd. and
  - China Sinogy Electric Engineering Co., Ltd.
- Of the 9 companies/JVs which submitted the prequalification documents, three (3) companies/JVs failed to provide the required data while two (2) failed to achieve the minimum overall score of 70%. As a result, a Request for Proposal ("RFP") was provided to and bids were received on October 17, 2017 from the following four (4) bidders:
  - JV of CHEC and GEDI,
  - Shanghai Electric,
  - Dongfang Electric,
  - Power China.
- For technical and financial bid evaluation an independent consulting firm registered with the Pakistan Engineering Council (**"PEC"**), Zeeruk International (Private) Limited (**"Zeeruk"**) was appointed by the Project Company.
- As per bidding guidelines outlined in the RFP, the technical bids were opened same day following the due date of submission. The contents of the bids were evaluated for responsiveness based on completeness of bid documents and qualifications of the bidders. The following table shows the technical scores at the conclusion of the technical evaluation of the bids. A minimum score of 60 percent was required to proceed to the commercial evaluation stage.

Name	Score
Dongfang Electric	75.28
JV of CHEC and GEDI	79.56
Power China	67.39
Shanghai Electric	59.31

- At the technical evaluation stage Shanghai Electric was disqualified due to scoring less than 60 percent.
- The financial evaluation was carried out for the remaining three (3) bidders. Power China, Dongfang Electric and JV of CHEC and GEDI. EPC prices (excluding taxes) offered by the three (3) bidders were as follows:

Name	Bid (USD million)
Dongfang Electric	415.33
JV of CHEC and GEDI	394.85
Power China	445.99

- The above bid prices were adjusted for missing Bill of Quantities ("BOQ") items, net capacity and net efficiency. The adjusted bid prices were as follows:

Name	Evaluated Bid Price (USD Million)
Dongfang Electric	437.56
JV of CHEC and GEDI	402.33
Power China	463.27

- Based on the financial evaluation criteria outlined in the RFP, the following scores were awarded to the respective bidders on the financial evaluation:

Name	Score
JV of CHEC and GEDI	96.67
Dongfang Electric	87.30
Power China	80.19

- Subsequent to the financial and technical evaluation a combined score was awarded by Zeeruk based on a 40% weightage for technical evaluation and 60% weightage for financial evaluation. The final scores and rankings of the bidders on the basis is presented in the table below:

Bidder	Score	Rank
JV of CHEC and GEDI	89.83	1
Dongfang Electric	82.49	2
Power China	75.07	3

5.1.1.2 EPC Cost Break Up

Following the Bidding Process, the Project Company after extended negotiations with the lowest bidder has been recently able to finalize the EPC price at a total cost of USD 369.89 million. Indicative breakdown of EPC cost is as follows:

Offshore Supply Contract Price: USD 250.16 Million and

Onshore Construction and Services Contract Price: USD 119.73 Million.

The Project Company has recently initialled the above contracts with the respective contractors and the finalized versions along with annexes shall be shared with NEPRA. The above EPC cost represents certain attributes which are typical to the Project, its location at Gwadar and the available infrastructure for the Project's development and its subsequent operation. These include a 2-unit configuration; requirement of a desalination system for construction and potable water; black start generator due to lack of grid connectivity; seawater FGD; cost of construction inputs at Gwadar; additional cost for human resource deployment; premium for technical services; extraordinary security requirements and costs; and the need for fast track development of the Project.

5.1.2 Custom Duties, Withholding Taxes and Sales Tax

Based on the above EPC cost breakup, the total duties and taxes for the Project amount to USD 40.11 million.

- Customs duties @ 5.00% of the offshore supply (USD 12.51 million) have been assumed in the Project cost which as per precedent will be adjusted at the time of COD on actual basis.
- The provisions of Upfront Tariff 2014 states that *"No withholding tax on local foreign contractors, sub-contractors, supervisory services and technical services provided by foreign (non-residents) entities has been assumed. Actual expenditure, if any, on this account will be included in the project cost at the time of COD on the basis of verifiable documentary evidence."* The Project Company has assumed that the provisions will apply in its case and an amount of USD 9.64 million has been budgeted for onshore construction and services in the Project cost. It is assumed that any change in the above assumption or applicability of any other tax mentioned above will be incorporated in the Project cost at COD through a one-time adjustment.
- The Project Company has assumed an amount of USD 17.96 million as provincial sales tax on onshore construction and services in the Project cost. This is essential since it is practically impossible to recover such construction period taxes in the operation period since sales tax is only levied on the energy portion of the tariff and after adjusting for inputs applicable to fuel pricing and variable O&M costs, no sales tax surplus is available to adjust the sales tax paid on capital costs during construction.

In addition, the Project Company requests any duties, charges or taxes in excess thereof (or any new taxes, charges or duties) be incorporated in the Project cost at COD through a one-time adjustment.

5.1.3 Non-EPC Cost

Non-EPC cost has been budgeted at USD 10.64 million which includes cost related to (i) private security to be arranged by the Project Company for a 30-month period (USD 5.77 million); (ii) satellite communication system at the Project site (USD 1.64 million); (iii) on-job training of 150 local engineers and personnel in China and at Project site (USD 2.33 million); and (iv) owner vehicles (USD 0.90 million).

5.1.4 Land

The total estimated land required for the Project is 207 acres, at a cost of approximately USD 5.00 million which includes land for the power complex, coal yard, ash yard, residential colony, public facilities, roads, open area etc. The land is being acquired by the Government of Balochistan under the LAA for and on behalf of the Project Company. Correspondence with GoB and details of land cost in this regard is attached as (**Annex J**). Land utilization of 207 acres by the Project is provided in **Annex K**.

5.1.5 Project Development Costs

Project Development Costs include (i) cost of owner's engineer and project manager (USD 10 million); (ii) cost of various Project studies including feasibility study, geological study, topographic study, jetty feasibility study, flood study, seismic study, marine hydrology study, grid interconnection study, coal assessment, detailed site investigations, environmental impact assessment, testing and modeling of marine intake and outfall structure etc. (USD 6.62 million); (iii) cost of local and foreign legal, technical, financial, tax, audit and other Project consultants (USD 3.81 million); and (iv) regulator fees and charges related to NEPRA, PPIB, SECP and other

government agencies (USD 0.6 million). It is requested that any fees and charges related to government agencies in excess of the aforementioned amounts be adjusted at COD through a one-time adjustment.

5.1.6 Company and Sponsor Costs

Company and sponsor costs include administrative costs expected to be incurred by the owner and sponsors during the development and construction period and have been budgeted at USD 26.84 million for a 42-month period. This includes cost related to salaries of local and expat employees, insurances, office and vehicle rentals, travel, utilities and other establishment costs.

5.1.7 Insurance during Construction

Insurance premiums (excluding SINOSURE premiums) to be incurred prior to COD have been estimated at 1.00% of EPC Cost (excluding any local taxes) and have been included as part of Project cost. The Project, in view of the PPA requirements and in accordance with the requirements typically set out by lenders funding the Project, intends to procure following insurances during the construction period:

i. Construction All Risk Insurance ("**CAR**");
ii. CAR Delay in Start-up Insurance;
iii. Marine and Inland Transit Insurance;
iv. Marine Delay-in-Start-up Insurance;
v. Comprehensive General Liability.

It is proposed that insurance will be adjusted at COD based on the finalized EPC cost.

5.1.8 O&M Mobilization Cost

About six months prior to commissioning, the O&M contractor is expected to be available on site to begin the process of acclimatizing and transitioning ownership of the complex from the EPC teams, which have been budgeted in the Project Cost at USD 6.49 million. Details of such costs are attached as **Annex L**.

5.1.9 Non-reimbursable Fuel and Start-up Cost prior to synchronization

This represents costs related to coal, diesel, consumables and other start-up costs expected to be incurred prior to the synchronization of the plant to the grid and have been budgeted at USD 3.44 million. It is proposed that such costs be adjusted at COD based on actuals.

5.1.10 SINOSURE Cost during Construction

As per requirement Chinese financial institutions are required to procure coverage under a SINOSURE insurance policy in case of overseas project lending. Similarly, state-owned enterprises undertaking overseas investments are also required to procure overseas investment insurance from SINOSURE. As per recent precedents, rate for such insurance has been assumed at 0.75% (including tax) and the insurance premium for the construction period for both debt and equity has been budgeted as part of the Project cost. In addition to the construction period, the policy will be applicable during the operations period, and a similar fee will be charged which has been discussed subsequently.

The Authority is aware that in certain cases depending on lender and sponsor requirements, the applicable SINOSURE policy may require that the entire premium be paid upfront and has

been budgeted by the projects in the project cost. Since the terms and modalities of the SINOSURE policy are still under discussions with the lenders and SINOSURE, it is proposed that a provision may be included in the tariff where an adjustment may be allowed in case of an upfront premium payment.

5.1.11 Financing Fee and Charges

This covers arrangement, commitment and other fees payable to the lending banks as well as fees payable to legal, technical, insurance and other advisors employed by the bank for the purposes of the financing. These fees have currently been budgeted at 3.00% of the debt amount (excluding any sales or withholding taxes). The same shall be adjusted at COD on the basis of actual on production of verifiable documentary evidence.

5.1.12 Interest during Construction ("IDC")

IDC has been calculated based on a 30-month construction period, 80:20 debt to equity ratio and financing from Chinese banks. A lending rate of 3-month LIBOR of 1.37% plus a spread of 4.00% has been assumed. A detailed Project cost disbursement plan and related IDC calculation is attached as **Annex M.**

Interest during construction shall be subject to adjustments based on firm offer from lending banks and actual debt disbursement schedule. In addition, IDC shall be subject to adjustment for variation in the 3-month LIBOR and PKR/USD exchange rate on a quarterly basis.

5.2 Capital Structure Assumptions

The Project is to be funded based on a debt to equity ratio of 80:20. Based on the financial structure the Sponsor shall subscribe an equity of USD 108.47 million in the project, while USD 433.89 million will be raised from Chinese lenders. A summary of the proposed capital structure is given in the table below:

Capital Structure	USD Million
Equity	108.47
Debt	433.89
Total Project Cost	542.36
Debt: Equity	80:20

Whereas the Project Company has assumed a debt to equity ratio of 80:20, discussions are still underway with the Project lenders on the terms of the financing. As per precedent, it is proposed that the Authority allow an adjustment in the debt to equity ratio based on final term sheet with the Project lenders subject to a maximum of 30% equity.

5.3 Financing Cost Assumptions

A total loan tenor of 15 years with a loan repayment period of 12.5 years after COD has been assumed for the Project, with repayment over the debt period through 50 annuity based quarterly instalments. Based on current indications from lenders, the Project is expected to be financed based on an interest cost of 3-month LIBOR plus 4.0% per annum.

5.4 Return on Equity ("ROE")

NEPRA in its Upfront Tariff for Coal Power Projects dated 26th June 2014, allowed a 17% USD based IRR for imported coal projects. Given the strategic importance of the Gwadar project and the inherent risks of the development and operation of the Project, a similar IRR of 17% has been assumed for the purpose of calculation of the tariff. For the purposes of IRR

calculation, a separate Return on Equity during Construction ("**ROEDC**") has been included in the proposed tariff. Calculation in this regard is attached as **Annex N**. ROEDC and ROE components are proposed to be adjusted at COD based on actual Project costs, finalized debt to equity ratio, actual equity disbursement schedule and PKR/USD exchange rate.

5.5 Fuel Cost

Fuel consumption for the plant has been based on a thermal efficiency of 37% (net). Since the Project is expected to primarily use coal from South Africa, the base coal price has been assumed for coal shipments out of Richard's Bay, South Africa. Calculation for the same is provided below:

FOB Coal Price (NAR 6,000 kcal/kg)[1]	USD 90.99/MT
Adjusted FOB Coal Price (NAR 5,500 kcal/kg)	USD 83.41/MT
Marine Freight including embarkation port charges and costs	USD 10.00/MT
Marine Insurance	0.10% of CIF Coal Price
Port Handling & Other Costs at Disembarkation Port	USD 5.50/MT
Custom Duty on Coal @ 3% of CIF coal price	USD 2.80/MT
Transportation Cost to Site	At Actual
Delivered Coal Price at Site	**USD 101.80/MT**

[1] Average API-4 index for the month of October 2017 for RB1 Coal

The Project is expected to receive coal at the nearby Gwadar Port and transport the same to the Project Site at a distance of approximately 40 km via trucks.

It is proposed that the FOB Coal Price and Marine Freight shall be adjusted based on applicable indices and formulas determined by NEPRA with a provision for discount or premium on FOB coal price. Port handling costs, port to site transportation costs, other port costs and any taxes and duties shall be claimed as part of the fuel cost at actual.

5.6 Operations and Maintenance ("O&M") Costs

The Project Company conducted a bidding process for the finalization of the O&M contractor of the Project. Five (5) companies namely SEPCO I, CHD Power Plant Operation Co. Ltd., Energy China Power Test Research Institute Co. Ltd, Si Chuan Nengtong Electric Technology Company Limited and Anhui No. 2 Electric Power Construction Company Limited were invited to bid for the Project. Bids were received from SEPCC I, CHD and Energy China and based on final evaluation, Energy China has been chosen as the O&M contractor for the Project. The total annual O&M cost budgeted for the Project is USD 12.76 million. The above amount does not include cost related to the Project Company, its employees and establishment which have been budgeted at USD 2.41 million. Security costs, typical for Gwadar, are under negotiation and are currently budgeted at USD 2.26 million. Summary of estimated O&M costs is as follows:

Item	Estimated Cost
Variable O&M Cost	USD 2.67 million
Variable O&M – Local	52%
Variable O&M – Foreign	48%
Fixed O&M Cost	USD 14.76 million
Fixed O&M – Local	34%
Fixed O&M – Foreign	66%

The Project Company is in process of finalizing the O&M contract, details of which will be shared with the Authority upon finalization. In summary, the above are expected to cover costs related to local and expatriate O&M staff, routine scheduled and maintenance, periodic overhauls, ash disposal, chemicals, consumables, tools, spare parts etc.

5.7 Insurance during Operations

Annual insurance cost during operations has been assumed at 1.00% of EPC Cost. The Project, in view of the PPA requirements and in accordance with the requirements typically set out by lenders funding the Project, intends to procure following insurances during the construction period:

i. All Risk Insurance;
ii. Business Interruption following All Risk;
iii. Machinery Breakdown;
iv. Business Interruption following Machinery Breakdown;
v. Comprehensive General Liability.

It is proposed that insurance will be adjusted at COD based on the finalized EPC cost.

5.8 Cost of Working Capital

Cost of working capital has been calculated based on a 90 days coal inventory and 30 days fuel cost receivable as has been allowed by Authority in previous cases. Interest on working capital has been calculated on the basis of 3-month KIBOR of 6.53% plus a spread of 2.00%.

5.9 SINOSURE Fee during Operations

As stated in Section 5.1.10, SINOSURE fee during operations on both debt and equity have been budgeted @ 0.75% of the insured amount of debt and equity, respectively. In case of debt, the insured amount comprises of opening debt balance and interest payable during the year, whereas in case of equity, such amount is based on equity invested by the Project Company. In case, the Project Company is required to make an upfront payment for the SINOSURE premium, no fee shall be payable during operations period.

6. One Time Adjustment

The Project Company requests NEPRA to allow a one-time adjustment on the underlying tariff assumptions at COD to the following items:

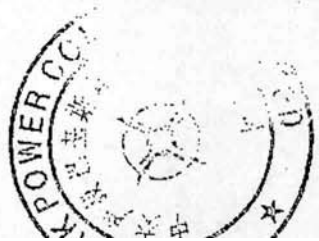
i. Total Project Cost to be adjusted based on actual Project cost and PKR/USD exchange rate applicable at the time of payment.
ii. Adjustment of debt to equity ratio of the Project as per the terms finalized with the Project lenders.
iii. Adjustment of SINOSURE premium based on actual amount payable to SINOSURE subject to a maximum of 0.75% per annum of insured amount in case of recurring payment and 7% of total debt servicing in case of upfront payment.
iv. Adjustment of debt servicing schedule based on actual debt to equity ratio, finalized Project cost and variation in LIBOR at the relevant date.
v. Adjustment of IDC on the basis of actual debt to equity ratio, debt disbursement schedule and changes in LIBOR during construction period.
vi. Adjustment of ROEDC on the basis of actual debt to equity ratio and equity disbursement schedule.

vii. Adjustment of custom duties, withholding taxes, sales tax and any other tax, duty, levy based on actual amounts paid on production of verifiable documentary evidence to the satisfaction of the Authority.
viii. Adjustment of land cost based on actual amounts paid to GOB.
ix. Adjustment of insurance during operation and construction at COD based on finalized EPC price.
x. Adjustment of financing fees and charges on actual amounts paid subject to a maximum of 3% of debt.
xi. Adjustment of non-reimbursable fuel and start-up cost before synchronization based on actual fuel cost and consumption.
xii. Any other adjustment typically allowed by the Authority in other Projects.

7. Pass-Through Items

Authority is requested to allow following cost components as pass-through to the Project Company on the basis of actual costs reasonably incurred by the Project Company or obligated to be paid in relation to the Project pursuant to Laws of Pakistan.

i. No provision for income tax, in whatsoever form, has been accounted for in the Project tariff. If the Project Company is obligated to pay any tax, the same shall be allowed to the Project Company as pass-through item.
ii. No withholding tax on dividends has been included in the Project tariff. Authority is requested to allow payment of withholding tax on dividend as pass-through at the time of actual payment of dividend.
iii. The payments to Workers Welfare Fund and Workers Profit Participation Fund have not been accounted for in the Project tariff and have been assumed to be reimbursed as pass-through at actual by the Power Purchaser.
iv. Zakat deduction on dividends as required under Zakat Ordinance is considered as a pass-through item.
v. No tax on income of CPPCL (including proceeds against sale of electricity to CPPA/NTDC) has been assumed. Corporate tax, turnover tax, general sales tax/provincial sales tax and all other taxes, excise duty, levies, fees etc by any federal/provincial entity including local bodies as and when imposed, shall be treated as pass-through item.
vi. No Balochistan Government taxes have been assumed in the Project tariff. In case Project Company is required to pay any such taxes, same shall be treated as pass-through item.
vii. Customs duties, local withholding tax and sales tax have been assumed as per the rates specified in this petition. Any changes will be considered pass-through under the tariff or reimbursed to the Project Company as a one-time adjustment.
viii. Any costs incurred by Project Company, which are required to be incurred by Power Purchaser pursuant to provisions of PPA shall also be treated as pass-through item.
ix. If the Project Company is required to make payment of withholding tax on SINOSURE Fee or any other debt payments to the Project lenders, the same shall be treated as pass through cost of the Project Company. The Power Purchaser shall reimburse to the Project Company the actual amount paid on a count of withholding tax after verification of relevant documentary evidence.
x. Any costs arising out of modifications/amendments by the Power Purchaser or any other governmental authority shall be considered pass-through to the Power Purchaser.



xi. Heat rate degradation, output degradations as well as partial load adjustment charge shall be allowed as per the manufacturer's curves.
xii. No free start-ups have been assumed in the O&M cost. If required, the same shall be billed at actuals to the Power Purchaser.
xiii. Security Charges payable for CPEC projects have not been considered in the Project cost and if applicable, will be reimbursed either through a separate tariff component or as a pass-through item.

8. Submission

In view of the aforesaid facts and grounds, the NEPRA Authority is requested to:

i. Allow the instant Tariff Petition;
ii. Allow full cost recovery of the Project cost as per this Tariff Petition;
iii. Grant tariff and other terms and conditions as per the provisions of this Tariff Petition;
iv. Allow Indexations, Escalations and Adjustments of the tariff components as per the provisions of this Tariff Petition;
v. Afford an opportunity of being heard including personal hearing before the Authority;
vi. Permit the Petitioner to submit further oral and written submissions with necessary documentary evidence;
vii. Permit the Petitioner to amend, modify, and to add further grounds in addition to the already recorded hereto; and
viii. Allow such other reliefs which are just, fair, proper in the interest of equity and justice.

For and on behalf of CIHC

Xu Jun
Chief Executive Officer

CIHC PAK POWER COMPANY LIMITED

Annex A

Reference Tariff Table

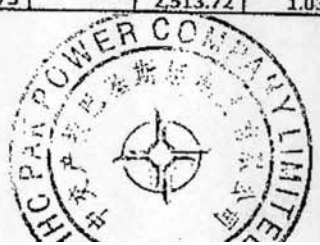
Year	Fuel Cost Component (PKR/kWh)	Variable O&M - Foreign (PKR/kWh)	Variable O&M - Local (PKR/kWh)	Energy Purchase Price (PKR/kWh)	Fixed O&M - Foreign (PKR/kW/hr)	Fixed O&M - Local (PKR/kW/hr)	Insurance (PKR/kW/hr)	Working Capital (PKR/kW/hr)	Sinosure (PKR/kW/hr)	Return on Equity (PKR/kW/hr)	Return on Equity during Construction (PKR/kW/hr)	Principal Repayment (PKR/kW/hr)	Interest Charges (PKR/kW/hr)	Capacity Purchase Price (PKR/kW/hr)	Capacity Purchase Price @ 85% (PKR/kWh)	Total Tariff (PKR/kWh)	Total Tariff (US Cents per kWh)
1	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.1774	0.8095	0.1961	1.1008	1.0010	4.2432	4.9920	9.6494	9.1899
2	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.1688	0.8095	0.1961	1.1611	0.9406	4.2347	4.9820	9.6394	9.1804
3	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.1598	0.8095	0.1961	1.2247	0.8770	4.2257	4.9714	9.6288	9.1703
4	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.1503	0.8095	0.1961	1.2918	0.8099	4.2162	4.9602	9.6176	9.1596
5	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.1403	0.8095	0.1961	1.3626	0.7391	4.2061	4.9484	9.6058	9.1484
6	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.1297	0.8095	0.1961	1.4373	0.6644	4.1956	4.9360	9.5934	9.1366
7	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.1186	0.8095	0.1961	1.5161	0.5857	4.1844	4.9229	9.5803	9.1241
8	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.1068	0.8095	0.1961	1.5991	0.5026	4.1727	4.9090	9.5665	9.1109
9	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0944	0.8095	0.1961	1.6868	0.4150	4.1603	4.8944	9.5519	9.0970
10	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0814	0.8095	0.1961	1.7792	0.3225	4.1472	4.8790	9.5365	9.0824
11	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0676	0.8095	0.1961	1.8767	0.2250	4.1334	4.8628	9.5203	9.0669
12	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0530	0.8095	0.1961	1.9795	0.1222	4.1188	4.8457	9.5031	9.0506
13	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0387	0.8095	0.1961	1.0301	0.0208	3.0536	3.5925	8.2499	7.8571
14	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
15	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
16	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
17	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
18	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
19	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
20	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
21	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
22	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
23	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
24	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
25	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
26	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
27	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
28	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
29	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
30	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
Average																	
1-13 Years	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.1144	0.8095	0.1961	1.4651	0.5558	4.0994	4.8228	9.4802	9.0288
14-30 Years	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0357	0.8095	0.1961	0.0000	0.0000	1.9998	2.3527	7.0101	6.6763
1-30 Years	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.0698	0.8095	0.1961	0.6349	0.2409	2.9096	3.4231	8.0805	7.6957
Levelized																	
1 - 30 Years	4.5196	0.0662	0.0717	4.6574	0.4276	0.2203	0.1624	0.1483	0.1062	0.8095	0.1961	1.0536	0.4978	3.6217	4.2608	8.9182	8.4935

Annex B

Debt Service Schedule (PKR Million)

Gross Capacity	300.00 MWs	US$/PKR Parity	105.00
Net Capacity	273.06 MWs	Debt	433.89 US$ Million
LIBOR	1.37%	Debt in Pak Rupees	45,558.37 Rs. Million
Spread over LIBOR	4.00%		
Total Interest Rate	5.37%		

Period	Principal PKR Million	Principal Repayment PKR Million	Interest PKR Million	Balance PKR Million	Debt Service PKR Million	Principal Repayment PKR/kW/hr	Interest PKR/kW/hr	Debt Servicing PKR/kW/hr
1	45,558.37	645.17	611.69	44,913.20	1,256.86			
2	44,913.20	653.83	603.03	44,259.37	1,256.86			
3	44,259.37	662.61	594.25	43,596.76	1,256.86			
4	43,596.76	671.51	585.36	42,925.26	1,256.86			
1st Year		**2,633.11**	**2,394.33**		**5,027.45**	**1.1008**	**1.0010**	**2.1017**
5	42,925.26	680.52	576.34	42,244.73	1,256.86			
6	42,244.73	689.66	567.20	41,555.08	1,256.86			
7	41,555.08	698.92	557.94	40,856.16	1,256.86			
8	40,856.16	708.30	548.56	40,147.86	1,256.86			
2nd Year		**2,777.40**	**2,250.05**		**5,027.45**	**1.1611**	**0.9406**	**2.1017**
9	40,147.86	717.81	539.05	39,430.04	1,256.86			
10	39,430.04	727.45	529.41	38,702.59	1,256.86			
11	38,702.59	737.22	519.64	37,965.38	1,256.86			
12	37,965.38	747.12	509.75	37,218.26	1,256.86			
3rd Year		**2,929.59**	**2,097.85**		**5,027.45**	**1.2247**	**0.8770**	**2.1017**
13	37,218.26	757.15	499.71	36,461.12	1,256.86			
14	36,461.12	767.31	489.55	35,693.80	1,256.86			
15	35,693.80	777.61	479.25	34,916.19	1,256.86			
16	34,916.19	788.06	468.81	34,128.13	1,256.86			
4th Year		**3,090.13**	**1,937.32**		**5,027.45**	**1.2918**	**0.8099**	**2.1017**
17	34,128.13	798.64	458.22	33,329.50	1,256.86			
18	33,329.50	809.36	447.50	32,520.14	1,256.86			
19	32,520.14	820.23	436.63	31,699.91	1,256.86			
20	31,699.91	831.24	425.62	30,868.67	1,256.86			
5th Year		**3,259.46**	**1,767.98**		**5,027.45**	**1.3626**	**0.7391**	**2.1017**
21	30,868.67	842.40	414.46	30,026.27	1,256.86			
22	30,026.27	853.71	403.15	29,172.56	1,256.86			
23	29,172.56	865.17	391.69	28,307.39	1,256.86			
24	28,307.39	876.79	380.07	27,430.60	1,256.86			
6th Year		**3,438.07**	**1,589.37**		**5,027.45**	**1.4373**	**0.6644**	**2.1017**
25	27,430.60	888.56	368.30	26,542.04	1,256.86			
26	26,542.04	900.49	356.37	25,641.54	1,256.86			
27	25,641.54	912.58	344.28	24,728.96	1,256.86			
28	24,728.96	924.84	332.03	23,804.13	1,256.86			
7th Year		**3,626.47**	**1,400.97**		**5,027.45**	**1.5161**	**0.5857**	**2.1017**
29	23,804.13	937.25	319.61	22,866.87	1,256.86			
30	22,866.87	949.84	307.02	21,917.04	1,256.86			
31	21,917.04	962.59	294.27	20,954.45	1,256.86			
32	20,954.45	975.51	281.35	19,978.93	1,256.86			
8th Year		**3,825.19**	**1,202.25**		**5,027.45**	**1.5991**	**0.5026**	**2.1017**
33	19,978.93	988.61	268.25	18,990.32	1,256.86			
34	18,990.32	1,001.89	254.98	17,988.43	1,256.86			
35	17,988.43	1,015.34	241.52	16,973.09	1,256.86			
36	16,973.09	1,028.97	227.89	15,944.12	1,256.86			
9th Year		**4,034.81**	**992.64**		**5,027.45**	**1.6868**	**0.4150**	**2.1017**
37	15,944.12	1,042.79	214.08	14,901.34	1,256.86			
38	14,901.34	1,056.79	200.07	13,844.55	1,256.86			
39	13,844.55	1,070.98	185.89	12,773.58	1,256.86			
40	12,773.58	1,085.36	171.51	11,688.22	1,256.86			
10th Year		**4,255.90**	**771.54**		**5,027.45**	**1.7792**	**0.3225**	**2.1017**
41	11,688.22	1,099.93	156.93	10,588.29	1,256.86			
42	10,588.29	1,114.70	142.16	9,473.59	1,256.86			
43	9,473.59	1,129.66	127.20	8,343.93	1,256.86			
44	8,343.93	1,144.83	112.03	7,199.10	1,256.86			
11th Year		**4,489.12**	**538.33**		**5,027.45**	**1.8767**	**0.2250**	**2.1017**
45	7,199.10	1,160.20	96.66	6,038.90	1,256.86			
46	6,038.90	1,175.78	81.08	4,863.12	1,256.86			
47	4,863.12	1,191.57	65.30	3,671.55	1,256.86			
48	3,671.55	1,207.56	49.30	2,463.99	1,256.86			
12th Year		**4,735.11**	**292.33**		**5,027.45**	**1.9795**	**0.1222**	**2.1017**
49	2,463.99	1,223.78	33.08	1,240.21	1,256.86			
50	1,240.21	1,240.21	16.65	-	1,256.86			
13th Year		**2,463.99**	**49.73**		**2,513.72**	**1.0301**	**0.0208**	**1.0509**



附件3：电价批复文件 Annex 15

National Electric Power Regulatory Authority
Islamic Republic of Pakistan

Registrar

NEPRA Tower, Attaturk Avenue (East), G-5/1, Islamabad
Ph: +92-51-9206500, Fax: +92-51-2600026
Web: www.nepra.org.pk, E-mail: registrar@nepra.org.pk

No. NEPRA/TRF-434/CPPCL-2018/19549-19551
December 19, 2018

Subject: **Determination of the Authority in the matter of Petition filed by CIHC Pak Power Company Limited for Approval of Generation Tariff for 300 MW (Gross) Coal-fired Power Plant at Gwadar, Balochistan** (Case No. NEPRA/TRF-434/CPPCL-2018)

Dear Sir,

Please find enclosed herewith the subject Determination of the Authority along with Annex-1 & 2 (46 pages) in Cas No. NEPRA/TRF-434/CPPCL-2018.

2. The Determination of the Authority is being intimated to the Federal Government for the purpose of notification in the official Gazette pursuant to Section 31 (7) of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

3. The Order of the Authority along with Annex-1 & 2 are to be notified in the official Gazette.

Enclosure: As above

19 12 18

(Syed Safeer Hussain)
Registrar

Secretary
Ministry of Ministry of Energy (Power Division),
'A' Block, Pak Secretariat
Islamabad

CC: 1. Secretary, Cabinet Division, Cabinet Secretariat, Islamabad.
2. Secretary, Ministry of Finance, 'Q' Block, Pak Secretariat, Islamabad.

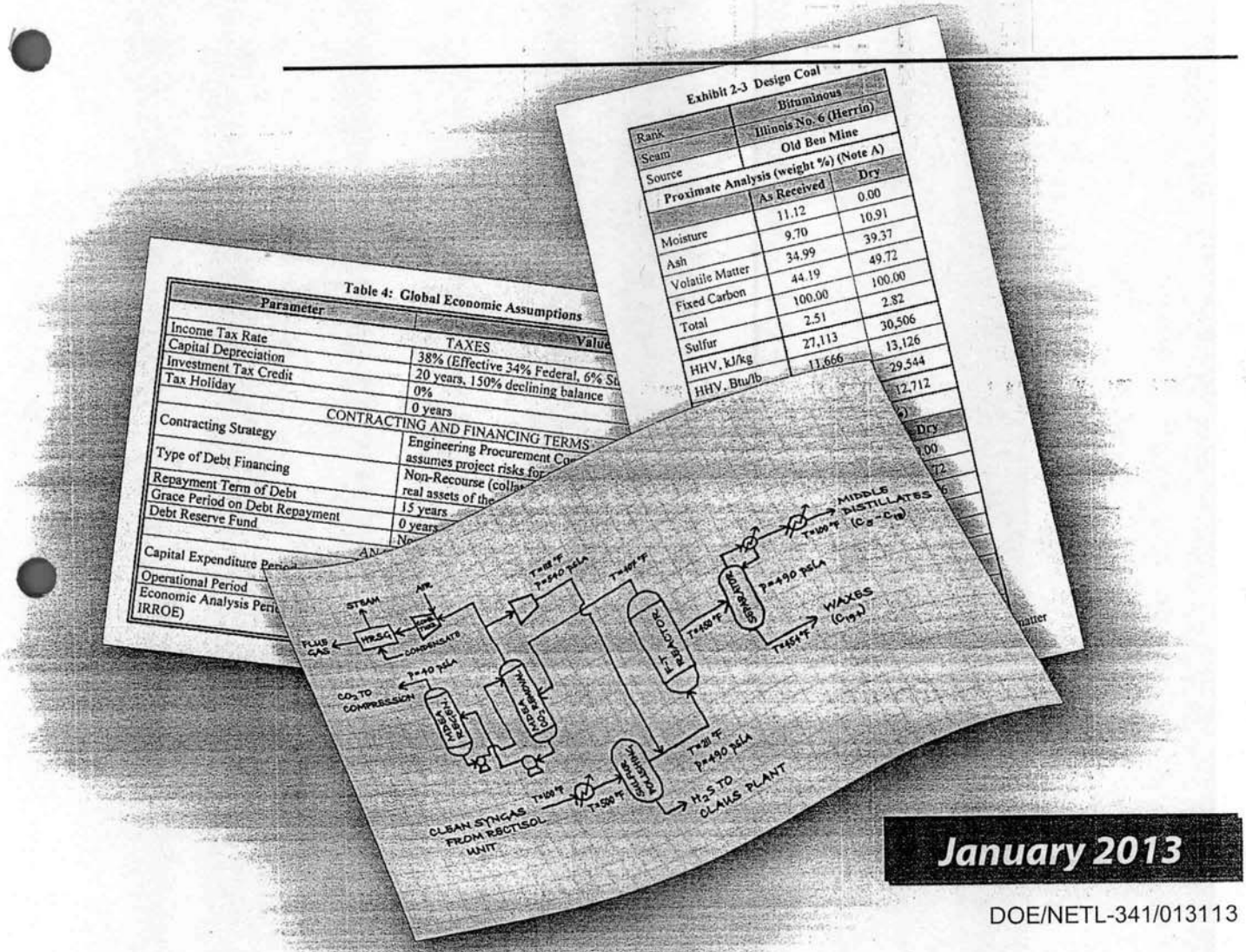
Annex C

the ENERGY lab

NETL

QUALITY GUIDELINES FOR ENERGY SYSTEM STUDIES

Capital Cost Scaling Methodology



January 2013

DOE/NETL-341/013113

NATIONAL ENERGY TECHNOLOGY LABORATORY

U.S. DEPARTMENT OF ENERGY

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Quality Guidelines for Energy System Studies
Capital Cost Scaling Methodology

DOE/NETL-341/013113

Final Report

January 31, 2013

NETL Contact:

James Black
General Engineer
Office of Program Planning & Analysis, Performance Division

National Energy Technology Laboratory
www.netl.doe.gov

Prepared by:

Energy Sector Planning and Analysis (ESPA)

Marc J. Turner
Booz Allen Hamilton, Inc.

Lora L. Pinkerton
WorleyParsons Group, Inc.

DOE Contract Number DE-FE0004001

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The authors wish to acknowledge the excellent guidance, contributions, and cooperation of the NETL staff, particularly:

James Black, NETL Technical Project Monitor
Kristin Gerdes
William Morgan Summers
John Wimer, NETL, Division Director,
Office of Program Performance and Benefits (OPPB)

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Table of Contents

List of Exhibits

Acronyms and Abbreviations

acfm	Actual cubic feet per minute
AGR	Acid gas removal
BEC	Bare erected cost
BFW	Boiler feed water
BOP	Balance of plant
C	Coefficient in equations
CFBC	Circulating fluidized bed combustion
Circ.	Circulating
CO_2	Carbon dioxide
CTG	Combustion turbine generator
DCF	Dry coal feed in equations
DOE	Department of Energy
EGR	Exhaust gas recycle
Equip.	Equipment
Exp	Exponent in equations
FG	Flue gas
FGD	Flue gas desulfurization
ft^3	cubic feet
gpm	Gallons per minute
Hg	Mercury
HGCU	Hot-gas-cleanup unit
HP	High pressure
HRSG	Heat recovery steam generator
IGCC	Integrated gasification combined cycle
ISO	International Standards Organization
kW	Kilowatt
kWe	Kilowatt electric
kWth	Kilowatt thermal
lb/hr	Pounds per hour
LHV	Lower heating value
LT	Low temperature
MDEA	Methyldiethanolamine
min	minute
Misc.	Miscellaneous
MMBtu/hr	Million British thermal units per hour
MVA	Mega volt-amps
MW	Megawatt
N/A	Not applicable
ND	North Dakota
NETL	National Energy Technology Laboratory
NGCC	Natural gas combined cycle
O_2	Oxygen
PC	Pulverized coal
PRB	Powder River Basin
RBEC	Reference plant bare erected cost in equations
RC	Reference cost in equations
RCon	Reference plant's contingency in equations
RP	Reference parameter in equations
RTPC	Reference total plant cost for subaccount in equations
SARU	Soot Ash Removal Unit
SC	Scaled cost in equations
SCon	Scaled plant's contingency, percent
SGC	Synthesis gas cooler
SP	Scaled parameter in equations
STG	Steam turbine generator
STPC	Scaled total plant cost for subaccount in equations
TG	Turbine Generator
TPC	Total plant cost
TPD	tons per day
TX	Texas
WGS	Water gas shift

1 Introduction

Costs are frequently required as part of systems analysis work at the National Energy Technology Laboratory (NETL). Many of the cost results provided as part of systems analysis work were created with the use of scaling, since obtaining new vendor-supplied cost quotes for each category developed by NETL would be prohibitively time consuming and costly. Additionally, many of the technologies being investigated by NETL have not progressed far enough to have quotable costs.

The costs are scaled from a quote for a similar plant configuration by use of various equations that typically employ at least one process parameter (e.g., coal-feed rate, oxidant-feed rate, etc.) and often an exponent. The primary purpose of the exponent is to account for economies of scale (i.e. as equipment size gets larger, it gets progressively cheaper to add additional capacity).

The purpose of this section of the Quality Guidelines is to provide a standard basis for scaling costs, with specific emphasis on scaling exponents. The intention of having a standardized document is to provide guidelines for proper procedures to reduce the potential of errors and increase credibility through consistency.

This document contains a listing of frequently used pieces of equipment and their corresponding scaling exponent for various plant types, along with their ranges of applicability. This document also details the equations to be used with each exponent.

The scaling exponents used in systems analysis work are logarithmically derived from previously obtained vendor supplied cost quotes using Equation 1.

Equation 1

$$Exp = \frac{\ln\left(RC_1/RC_2\right)}{\ln\left(RP_1/RP_2\right)}$$

Where:

- Exp – Exponent
- RC – Reference Cost
- RP – Reference Parameter

Exhibit 1-1 provides a listing of the categories used in this document and a description of the types of technologies to which the associated exponents are applicable. Exhibit 1-2 provides a listing of reference reports for the various categories.

The listings are divided into three major technologies frequently analyzed at NETL: combustion [pulverized coal (PC) and circulating fluidized bed combustion (CFBC)]; integrated gasification combined cycle (IGCC); and natural gas combined cycle (NGCC).

Exhibit 1-1 Category matrix

Category	Technologies
	PC/CFBC
1	Supercritical PC, air-fired, with and without CO_2 capture, Illinois No. 6 coal with hybrid poplar
	Supercritical PC, oxy-fired, with CO_2 capture, Illinois No. 6 coal with hybrid poplar
	Supercritical and ultra-supercritical[1] PC, oxy-fired, with CO_2 capture, Illinois No. 6 coal
2	CFBC, air-fired, with and without CO_2 capture, PRB and ND Lignite coals
	CFBC, oxy-fired, with CO_2 capture, PRB and ND Lignite coals
3	Supercritical PC, air-fired, with and without CO_2 capture, ND Lignite and PRB coals
	Ultra-supercritical PC[1], air-fired, with and without CO_2 capture, ND Lignite and PRB coals
	Supercritical PC, oxy-fired, with CO_2 capture, ND Lignite and PRB coals
	Ultra-supercritical PC[1], oxy-fired, with CO_2 capture, ND Lignite and PRB coals
4	Supercritical and ultra-supercritical PC[1], air-fired, with and without CO_2 capture, Illinois No. 6 coal
5	Subcritical PC, air-fired, with and without CO_2 capture, Illinois No. 6 coal
	IGCC
6	Single-stage, dry-feed, oxygen-blown, down-flow gasifier with and without CO_2 capture, PRB and ND Lignite coals
7	Two-stage, slurry-feed, oxygen-blown gasifier with and without CO_2 capture, PRB coal
	Single-stage, slurry-feed, oxygen-blown gasifier with and without CO_2 capture, Illinois No. 6 coal
8	Single-stage, dry-feed, oxygen-blown, up-flow gasifier, with CO_2 capture, PRB coal with and without switchgrass
	Single-stage, dry-feed, oxygen-blown, up-flow gasifier with CO_2 capture, Illinois No. 6 coal with switchgrass
	Single-stage, dry-feed, oxygen-blown, up-flow gasifier, with and without CO_2 capture, PRB and ND Lignite coals
	Single-stage, dry-feed, oxygen-blown, up-flow gasifier without CO_2 capture, Illinois No. 6 coal
9	Transport gasifier, air- and oxygen-blown, with and without CO_2 capture, PRB and TX Lignite coals
	Transport gasifier, oxygen-blown with CO_2 capture, TX Lignite coal, with hybrid poplar
	NGCC
10	Natural gas, air-fired, with and without CO_2 capture
	Natural gas, air-fired with CO_2 capture and gas recycle

[1] Ultra-supercritical PC plants have a 10-percent process contingency applied to line item 4.1 (PC Boiler and Accessories) and a 15-percent process contingency applied to line item 8.1 (Steam Turbine Generator and Accessories).

Exhibit 1-2 Reference cost estimates

Category	Technologies Report Hyperlinks
PC/CFBC	
1	*Cost and Performance Baseline for Fossil Energy Power Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity*[1]
	Greenhouse Gas Reductions in the Power Industry Using Domestic Coal and Biomass NETL – Volume 2: PC Plants[2]
	Advanced Oxycombustion Technology for Bituminous Coal Power Plants: An R&D Guide[3]
2	*Cost and Performance Baseline for Fossil Energy Plants – Volume 3: Low Rank Coal and Natural Gas to Electricity*[4]
	Advanced Oxycombustion Technology for Bituminous Coal Power Plants: An R&D Guide[3]
3	*Cost and Performance Baseline for Fossil Energy Plants – Volume 3: Low Rank Coal and Natural Gas to Electricity*[4]
4	*Cost and Performance Baseline for Fossil Energy Power Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity*[1]
5	*Cost and Performance Baseline for Fossil Energy Power Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity*[1]
IGCC	
6	*Cost and Performance Baseline for Fossil Energy Plants – Volume 3: Low Rank Coal and Natural Gas to Electricity*[4]
7	*Cost and Performance Baseline for Fossil Energy Plants – Volume 3: Low Rank Coal and Natural Gas to Electricity*[4]
8	*Cost and Performance Baseline for Fossil Energy Plants – Volume 3: Low Rank Coal and Natural Gas to Electricity*[4]
	Cost and Performance Baseline for Fossil Energy Power Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity[1]
9	*Cost and Performance Baseline for Fossil Energy Plants – Volume 3: Low Rank Coal and Natural Gas to Electricity*[4]
NGCC	
10	*Cost and Performance Baseline for Fossil Energy Plants – Volume 3: Low Rank Coal and Natural Gas to Electricity*[4]
	Cost and Performance Baseline for Fossil Energy Power Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity[1]

1.1 Limitations of Scaling Approach

It is important to note that when scaling costs, the technologies must be as similar as possible. For instance, if scaling a plant that fires Illinois No. 6, both the scaling exponents and the reference cost should be for a plant that fires Illinois No. 6. The same is true for the following specifications as well:

- Oxidant type (Air or Oxygen)
- Elevation/Location (International Standards Organization [ISO], North Dakota, Montana, etc.)
- Plant type (Sub-critical, supercritical, ultra-supercritical, etc.)
- Technology type (PC, IGCC, NGCC, etc.)
- Emissions control technologies (with/without CO_2 capture, with/without flue gas desulfurization [FGD], etc.)

For many of the items provided in this report, the approach presented scales on a single parameter for a given account. In reality, some accounts, particularly some of the major equipment items, may be impacted by more than one parameter. For example, a line item may be scaled on one or more flows/outputs but should, in reality, be scaled on multiple flows/outputs and on both pressure and temperature, or thermal duty and delta temperature. While the single-parameter approach can be used for high-level scaling, it is recommended that individual items/systems be scaled from the most similar reference possible, particularly for the cost drivers.

There are limitations on the ranges that can accurately be addressed by the scaling approach. There can be step changes in pricing at certain equipment sizes that may not be captured by the scaling exponents. Care should be taken in applying the scaling factors when there is a large percentage difference between the scaling parameters. This is particularly true for the major equipment items. For example, it is known that the combustion turbine is an incremental cost and is specific to one level of performance.

The configuration also has a significant impact on costs. In addition to the base scaling, adjustments must be made for considerations such as number of trains for a particular system and equipment redundancy (i.e. 2 x 100% versus 3 x 50%).

The plant location is another issue that must be kept in mind when scaling costs. Project location and labor basis can have a significant impact on overall project costs. An additional adjustment to the labor component may be required to reflect local wage rates, local labor productivity, and a union versus non-union environment.

It is imperative that the reader understand that even subtle differences in equipment specifications can result in significant cost impacts. Adjustments, often in the form of additions or deductions, must be incorporated to address these elements. These could include items such as unique site considerations (piles, access requirements, salt water environment), or specific equipment requirements (stack height, re-heat versus non re-heat, single pressure versus multiple pressure, turbine backpressure).

Finally, the cost basis date must be considered. Equipment, material, and labor costs may need to be escalated or de-escalated to adjust for the differences between the cost basis date for the

scaled estimate and the reference estimate. Additionally, significant elapsed time between the reference cost date and the desired date for the scaled estimate could potentially encompass technology or approach changes for a specific item and/or system.

In general, the approach presented in this report is valid for high-level evaluation only. The accuracy of the factored estimate will be less than or equal to that for a reference estimate.

1.2 Methodology

When developing a cost estimate for a plant that requires scaled costing, determine the category type from the category matrix in Exhibit 1-1 that exhibits as much commonality as possible when compared to the plant of interest. Once the category type has been determined, an estimate for a plant of the same type must be obtained for use as a reference. A listing of reports containing example reference cost estimates for each category type is provided in Exhibit 1-2. Reference cost estimates may also be found on the NETL Energy Analysis web[1].

If the plant of interest does not match any of the available reference cost estimates, select one that most suitably matches, taking care to minimize the impact from the limitations of the scaling approach detailed in Section 2.

For plants of interest that differ significantly from any available reference cost estimates, the plant of interest may still have many of the same subsystems as one or more of the reference cost estimates. If so, then the reference cost estimate used may be a combination of various individual reference cost estimates, matched based on subaccount.

Using the category type obtained from the category matrix, utilize Exhibit 2-2 through Exhibit 2-43 to obtain the scaling parameters, exponents, and coefficients. The scaling parameter values associated with the reference cost estimate will be taken from the report from which the reference cost estimate was obtained.

Determine the scaling parameter values for the plant of interest and compare them to the range of applicability provided in Exhibit 2-2 through Exhibit 2-43. If the value is outside the recommended range, significant deviation from realistic results could occur.

Once the scaling parameters, exponents, and coefficients as well as the reference cost and scaling parameter values are obtained, the scaled cost estimate can be developed by utilizing the equations provided in Section 2. Specific guidelines are available in subsections, as follows:

Section 2.1 "PC and CFBC"

Section 2.2 "IGCC"

Section 2.3 "NGCC"

The following subsection provides an example for developing cost estimates.

[1] http://www.netl.doe.gov/research/energy-analysis

1.3 Scaled Cost Estimate Development Examples

The plant of interest:

The plant of interest is an oxygen-blown two-stage slurry feed gasifier, firing Powder River Basin (PRB) coal at ISO elevation. The plant is equipped with CO_2 capture and compression systems and utilizes a wet cooling tower.

Category type:

Category 7 from the category matrix (Exhibit 1-1) most suitably matches the plant of interest as it shares the following items in common:

1) Two-stage slurry feed gasifier
2) Oxygen-blown
3) CO_2 capture
4) PRB coal

Reference plant:

No exact match is available for a 'reference plant' as a comparison to the 'plant of interest'. Therefore, the 'reference plant' will have to be a combination of various 'reference plants' based on subaccount matches. The reference plants selected are Case S4B from the Category 7 report "*Cost and Performance Baseline for Fossil Energy Plants – Volume 3: Low Rank Coal and Natural Gas to Electricity*" [4] (Exhibit 1-2) and Case 4 from the Category 8 report, "*Cost and Performance Baseline for Fossil Energy Power Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity*" [1] (Exhibit 1-2).

Case 4 matches:

1) Cooling type
2) Elevation
3) CO_2 capture
4) Gasifier type

Case S4B matches:

1) Coal type
2) CO_2 capture
3) Gasifier type

It was decided that all accounts that have direct influence from coal will be scaled using Case S4B. All other accounts will be scaled using Case 4.

Accounts scaled using Case S4B include:

1) Coal and Sorbent Handling
2) Coal and Sorbent Preparation and Feed
4) Gasifier and Accessories
5A) Gas Cleanup and Piping
6) Combustion Turbine and Accessories

The section that will be utilized in the example will be Account 5 "Gas Cleanup and Piping"

Obtain Scaling Parameters

Exhibit 2-21 contains the scaling parameters, exponents, coefficients, and ranges for Account 5 of the selected category 7 plant type.

Exhibit 1-3 provides the account number, item description, scaling parameter, exponent and coefficient, range of applicability, reference parameter value, reference cost, and scaling parameter value.

Exhibit 1-3 Example Account 5: Parameter listing

Account Number	Item Description	Parameter[1]	Exponent [Coefficient][1]	Range[1]	Reference Parameter[2]	Reference Cost (Equipment/ TPC)[2]	Scaling Parameter[3]
5A.1	Selexol (Double)	Gas flow to AGR, acfm	0.79	5,000 – 30,000	11,389	$73,047	12,068
5A.2	Elemental Sulfur Plant	Sulfur Production, lb/hr	0.67	200 – 44,000	4,901	$5,613	5,339
5A.3	Mercury Removal	Hg bed carbon fill, ft^3	See Note[4]	2,000 – 35,000	N/A	$1,328/$3,218	3,916
5A.4	Shift Reactors	WGS Catalyst volume, ft^3	0.80	1,000 – 11,000	6,257	$8,762	6,692
5A.5	Blowback Gas Systems	Candle filter flow rate, acfm	0.30	2,000 – 96,000	24,282	$2,030	26,838
5A.6	Fuel Gas Piping	Fuel gas flow, lb/hr	0.72	185,000 – 2,490,000	202,347	$0	221,487
5A.9	HGCU Foundations	Sulfur Production, lb/hr	0.79	200 – 44,000	4,901	$0	5,339

[1] Information from exhibits in this document
[2] Information from the 'reference' plant report
[3] Scaling parameter from the 'plant of interest'
[4] The exponent 1.57 is used with PRB coal, the exponent 1.64 is used with Illinois No. 6 coal without CO_2 capture, and the exponent 1.59 is used with Illinois No. 6 coal with CO_2 capture. The coefficient 0.0141 is used with all instances.

Calculating scaled cost estimates

Unless otherwise specified, calculating the material cost, labor costs, and equipment cost differs only in the value used as the reference plants reference cost (RC). When calculating the scaled plant's equipment cost, one should use the reference plant's equipment cost as the reference cost; likewise, when calculating the scaled plant's material cost, one should use the reference plant's material cost as the reference cost, etc. The sum of these costs is the bare erected cost (BEC).

The process contingency, project contingency, engineering construction management, home office, and fee are based on a percentage of the BEC. These percentages can be calculated by using the following equation:

Equation 2

$$SCon = \frac{RCon}{RBEC}$$

Where:

- SCon – Scaled plant's contingency, %
- RCon – Reference plant's contingency, $
- RBEC – Reference plant's BEC, $

The scaled plant's contingency percentage is multiplied by the scaled plant's BEC to get the scaled plant's contingency dollar value. The process is repeated for each of the individual contingencies.

The sum of the BEC and the contingencies is the total plant cost (TPC) for each sub-account.

The example calculations will focus on determining a scaled Equipment Cost for each subaccount. As such, subaccounts 5A.6 and 5A.9 will not be demonstrated, as their reference value is $0.

By comparing the scaling parameter to the range of applicability, it is confirmed that it is suitable to develop a scaled cost estimate for the plant of interest using the scaling parameters, exponents, and coefficients obtained from within this document.

Based on the general guidelines provided in Section 2 along with the specific guidelines provided in section 2.2 for IGCC plants, the following equations will be utilized:

For all categories, unless otherwise specified, Equation 3 is used to scale costs.

Equation 3

$$SC = RC * \left(\frac{SP}{RP}\right)^{Exp}$$

Where:

- Exp – Exponent
- RC– Reference cost
- RP – Reference Parameter
- SC – Scaled cost
- SP – Scaling parameter

For IGCC categories, use Equation 4 for items that utilize a coefficient in addition to an exponent.

Equation 4

$$SC = \frac{RC}{RTPC} * C * SP^{Exp}$$

Where:

- C – Coefficient
- Exp – Exponent
- RC– Reference cost
- RTPC – Reference total plant cost for subaccount
- SC – Scaled cost
- SP – Scaling parameter

Account 5A.1 will use Equation 3 with the parameter "Gas flow to AGR" in actual ft^3/min. The equation is as follows:

Example 1

$$SC = \$76{,}466 = \$73{,}047 * \left(\frac{12{,}068 \frac{ft^3}{min}}{11{,}389 \frac{ft^3}{min}} \right)^{0.79}$$

Based on the Note for Account 5A.3, it contains a coefficient. Therefore, this account will use Equation 4 with the parameter "Hg bed carbon fill" in ft^3. The equation is as follows:

Example 2

$$SC = \$2{,}544 = \frac{\$1{,}328}{\$3{,}218} * 0.0141 * 3{,}916 ft^3{}^{1.57}$$

All other subaccounts will use Equation 3 as was demonstrated in Example 1. Exhibit 1-4 provides the results of the calculations and compares them to the reference value.

Exhibit 1-4 Example Account 5: Parameter listing

Account Number	Item Description	Parameter	Reference Parameter	Reference Cost (Equipment/)	Scaling Parameter	Scaled Cost (Equipment)
5A.1	Selexol (Double)	Gas flow to AGR, acfm	11,389	$73,047	12,068	$76,466
5A.2	Elemental Sulfur Plant	Sulfur Production, lb/hr	4,901	$5,613	5,339	$5,944
5A.3	Mercury Removal	Hg bed carbon fill, ft^3	N/A	$1,328	3,916	$2,544
5A.4	Shift Reactors	WGS Catalyst volume, ft^3	6,257	$8,762	6,692	$9,246
5A.5	Blowback Gas Systems	Candle filter flow rate, acfm	24,282	$2,030	26,838	$2,092

2 Scaling Exponents and Equations

In all instances, the range is intended to present the reader with the ranges at which the exponents have already been utilized. It is expected that the ranges, in reality, would be capable of being applied to the median range ± 25 percent.

For all categories, unless otherwise specified, Equation 3 is used to scale costs.

Equation 3

$$SC = RC * \left(\frac{SP}{RP}\right)^{Exp}$$

Where:

- Exp – Exponent
- RC– Reference cost
- RP – Reference Parameter
- SC – Scaled cost
- SP – Scaling parameter

2.1 PC and CFBC

For PC and CFBC categories, use Equation 5 for items that utilize a coefficient in addition to an exponent. In the "Scaling parameters and exponents" tables below, the values presented within brackets [] are coefficients.

Equation 5

$$SC = \frac{RC}{RTPC} * (C * SP)^{Exp}$$

Where:

- C – Coefficient
- Exp – Exponent
- RC– Reference cost
- RTPC – Reference Total Plant Cost of subaccount
- SC – Scaled cost
- SP – Scaling parameter

Exhibit 2-1 provides the category matrix for the PC and CFBC categories.

Exhibit 2-1 Category matrix: PC and CFBC

Category	Technologies
1	Supercritical PC, air-fired, with and without CO_2 capture, Illinois No. 6 coal with hybrid poplar
	Supercritical PC, oxy-fired, with CO_2 capture, Illinois No. 6 coal with hybrid poplar
	Supercritical and ultra-supercritical[1] PC, oxy-fired, with CO_2 capture, Illinois No. 6 coal
2	CFBC, air-fired, with and without CO_2 capture, PRB and ND Lignite coals
	CFBC, oxy-fired, with CO_2 capture, PRB and ND Lignite coals
3	Supercritical PC, air-fired, with and without CO_2 capture, ND Lignite and PRB coals
	Ultra-supercritical PC[1], air-fired, with and without CO_2 capture, ND Lignite and PRB coals
	Supercritical PC, oxy-fired, with CO_2 capture, ND Lignite and PRB coals
	Ultra-supercritical PC[1], oxy-fired, with CO_2 capture, ND Lignite and PRB coals
4	Supercritical and ultra-supercritical[1] PC, air-fired, with and without CO_2 capture, Illinois No. 6 coal
5	Subcritical PC, air-fired, with and without CO_2 capture, Illinois No. 6 coal

Exhibit 2-2 through Exhibit 2-15 contains the scaling parameters and exponents that are suitable for PC and CFBC plants at the given ranges.

[1] Ultra-supercritical PC plants have a 10 percent process contingency applied to line item 4.1 (PC Boiler and Accessories) and a 15 percent process contingency applied to line item 8.1 (Steam Turbine Generator and Accessories).

Exhibit 2-2 Scaling parameters and exponents for categories 1-5: "Fuel and Sorbent Handling"

Account Number	Item Description	Parameter	Exponent					Range
	Category	1-5	1	2	3	4	5	1-5
1	FUEL & SORBENT HANDLING							
1.1	Coal Receive & Unload	Coal Feed Rate, lb/hr	0.62					275,000 – 1,110,000
1.2	Coal Stackout & Reclaim	Coal Feed Rate, lb/hr	0.62					275,000 – 1,110,000
1.3	Coal Conveyors & Yard Crushing	Coal Feed Rate, lb/hr	0.62					275,000 – 1,110,000
1.4	Other Coal Handling	Coal Feed Rate, lb/hr	0.62					275,000 – 1,110,000
1.5	Biomass Receiving & Processing	Biomass Feed Rate, lb/hr	See Note[1]					412,000 – 616,000
1.6	Sorbent Receive & Unload	Limestone Feed Rate, lb/hr	0.64					9,000 – 63,000
1.7	Sorbent Stackout & Reclaim	Limestone Feed Rate, lb/hr	0.64					9,000 – 63,000
1.8	Sorbent Conveyors	Limestone Feed Rate, lb/hr	0.64					9,000 – 63,000
1.9	Other Sorbent Handling	Limestone Feed Rate, lb/hr	0.64					9,000 – 63,000
1.10	Coal & Sorbent Handling Foundations	Coal and Limestone Feed Rate, lb/hr	0.62					302,000 – 1,150,000

Equation 6

$$SC = 215,062 * \left(\frac{SP}{2000} * 24\right)^{Exp}$$

Equation 7

$$SC = 132,454 * \left(\frac{SP}{2000} * 24\right)^{Exp}$$

[1] Only applicable to plants co-firing hybrid poplar. Use Equation 6 with exponent 0.37 for equipment and Equation 7 with exponent 0.45 for direct labor. Values provided in $1,000 (2007$).

Exhibit 2-3 Scaling parameters and exponents for categories 1-5: "Fuel and Sorbent Prep and Feed"

Account Number	Item Description	Parameter	Exponent					Range
	Category	1-5	1	2	3	4	5	1-5
2	FUEL & SORBENT PREP & FEED							
2.1	Coal Crushing & Drying	Coal Feed Rate, lb/hr	0.66					275,000 – 1,110,000
2.2	Prepared Coal Storage & Feed	Coal Feed Rate, lb/hr	0.66					275,000 – 1,110,000
2.5	Biomass Drying	Biomass Feed Rate, lb/hr	0.66[1]					412,000 – 616,000
2.6	Biomass Pelletization	Biomass Feed Rate, lb/hr	0.66[2]					412,000 – 616,000
2.7	Prepared Biomass Storage & Feed	Biomass Feed Rate, lb/hr	0.66					412,000 – 616,000
2.8	Sorbent Prep Equipment	Limestone Feed Rate, lb/hr	0.65					10,000 – 57,000
2.9	Sorbent Storage & Feed	Limestone Feed Rate, lb/hr	0.65					10,000 – 57,000
2.12	Coal & Sorbent Feed Foundation	Coal and Limestone Feed Rate, lb/hr	0.64					303,000 – 1,150,000

Equation 8

$$SC = \mathrm{C} * \left(\frac{SP}{2000} * 24\right)^{Exp}$$

Equation 9

$$SC = RC * \left(\frac{SP}{10 * 1.1 * 2000}\right)^{Exp}$$

[1] Only applicable to plants co-firing hybrid poplar. Use Equation 8 with a coefficient of 7.0428 for equipment and 1.3724 for direct labor. Values provided in $1,000 (2007$).

[2] Only applicable to plants co-firing hybrid poplar. Use Equation 9 for equipment.

Exhibit 2-4 Scaling parameters and exponents for categories 1-5: "Feedwater and Miscellaneous BOP Systems"

Account Number	Item Description	Parameter	Exponent					Range
Category		1-5	1	2	3	4	5	1-5
3	FEEDWATER & MISC. BOP SYSTEMS							
3.1	Feedwater System	HP BFW Flow Rate, lb/hr	0.68					1,960,000 – 5,600,000
3.2	Water Makeup & Pretreating	Raw Water Makeup, gpm	0.71					2,000 – 11,000
3.3	Other Feedwater Subsystems	HP BFW Flow Rate, lb/hr	0.68					1,960,000 – 5,600,000
3.4	Service Water Systems	Raw Water Makeup, gpm	0.71					2,000 – 11,000
3.5	Other Boiler Plant Systems	HP BFW Flow Rate, lb/hr	0.75					1,960,000 – 5,600,000
3.6	FO Supply Sys & Nat Gas	Total Fuel Feed, lb/hr	0.25					410,000 – 1,110,000
3.7	Waste Treatment Equipment	Water to Treatment, lb/hr	0.71					100 – 1,210,000
3.8	Misc. Power Plant Equipment	Total Fuel Feed, lb/hr	0.25					410,000 – 1,110,000

Exhibit 2-5 Scaling parameters and exponents for categories 1-5: "PC Boiler and Accessories"

Account Number	Item Description	Parameter	Exponent					Range
Category		1-5	1	2	3	4	5	1-5
4	PC BOILER & ACCESSORIES							
4.1	PC Boiler & Accessories	See Note[1]	0.69					See Note[1]
4.2	ASU/Oxidant Compression	O_2 Flow Rate, TPD	0.60					13,200 – 15,100

[1] CFBC plants use the sum of limestone and coal feed rates (lb/hr) with the total ranging from 303,000 – 1,150,000; Oxy-fired PC with no biomass use coal-feed rates (lb/hr) ranging from 275,000 – 1,112,000; PC air-fired and PC with biomass use high pressure (HP) boiler feed water (BFW) flow rates (lb/hr) ranging from 1,958,000 – 5,603,000.

Exhibit 2-6 Scaling parameters and exponents for categories 1-5: "Flue Gas cleanup"

Account Number	Item Description	Parameter	Exponent [Coefficient]					Range
Category		1-5	1	2	3	4	5	1-5
5	FLUE GAS CLEANUP							
5.1	Absorber Vessels & Accessories	FGD Exit Flow, acfm {Limestone Feed Rate, lb/hr}	0.73 [3.08]	N/A	0.59 [23.75][1]	{0.73}	0.73	1,020,000 – 2,560,000 9,000 – 63,400
5.2	Other FGD	FGD Exit Flow, acfm {Limestone Feed Rate, lb/hr}	0.73 [0.28]	N/A	0.49[2]	{0.73}	0.73	1,020,000 – 2,560,000 9,000 – 63,400
5.3	Bag House & Accessories	Baghouse Flow, acfm	0.78 [0.47]	N/A	N/A	0.79	0.79	1,390,000 – 2,560,000
5.4	Other Particulate Removal Materials	Baghouse Flow, acfm	0.77	N/A	0.40 [112.22][3]	0.79	0.79	1,390,000 – 2,560,000
5.5	Gypsum Dewatering System	Gypsum Flow, lb/hr	0.62	N/A	N/A	0.58	0.60	42,900 – 96,600

Exhibit 2-7 Scaling parameters and exponents for categories 1-5: "CO_2 Removal and Compression"

Account Number	Item Description	Parameter	Exponent [Coefficient]					Range
Category		1-5	1	2	3	4	5	1-5
5B	CO_2 REMOVAL & COMPRESSION							
5B.1	CO_2 Condensing Heat Exchanger	Heat Duty, MMBtu/hr	0.80	0.80	0.80			200 – 600
	CO_2 Removal System	CO_2 Flowrate (lb/hr)/ Inlet to Absorber, acfm	0.60[4]	N/A		0.60[4]	0.60[4]	445,000 – 689,000/ N/A[5]
5B.2	CO_2 Compression & Drying	CO_2 Captured, lb/hr	0.61					850,000 – 2,290,000

[1] Ultra-supercritical plants use a coefficient of 25.9090 and an exponent of 0.5810.
[2] Ultra-supercritical plants use an exponent of 0.46.
[3] Ultra-supercritical plants use a coefficient of 92.44 and an exponent of 0.4152.
[4] 40% of cost is applied to gas flow and the remainder applied to CO_2 capture.
[5] Range has not yet been developed as parameter has not been implemented to date.

Exhibit 2-8 Scaling parameters and exponents for categories 1-5: "HRSG, Ducting, and Stack"

Account Number	Item Description	Parameter	Exponent [Coefficient]					Range
Category		1-5	1	2	3	4	5	1-5
7	HRSG, DUCTING & STACK							
7.1	Flue Gas Recycle Heat Exchanger	Heat Duty, MMBtu/hr	0.80					20 – 1,000
7.3	Ductwork	Total Fuel Feed, lb/hr	0.38 [126.25]	0.38 [126.25]	0.38 [126.25]	0.29	0.29	410,000 – 1,110,000
7.4	Stack	Stack Flow, acfm	0.48 [19.52]	0.48 [19.52]	0.48 [19.52]	0.06	0.06	378,000 – 1,840,000
7.9	HRSG, Duct & Stack Foundations	Total Fuel Feed, lb/hr	0.14 [471.71]	0.14 [471.71]	0.14 [471.71]	0.06	0.06	410,000 – 1,110,000

Exhibit 2-9 Scaling parameters and exponents for categories 1-5: "Steam Turbine Generator"

Account Number	Item Description	Parameter	Exponent					Range
Category		1-5	1	2	3	4	5	1-5
8	STEAM TURBINE GENERATOR							
8.1	Steam TG & Accessories	Turbine Capacity, MW	0.70					600 – 800
8.2	Turbine Plant Auxiliaries	Turbine Capacity, MW	0.70					600 – 800
8.3a	Condenser & Auxiliaries	Condenser Duty, MMBtu/hr	0.67	0.67	0.67	0.67	0.40	1,000 – 3,000
8.3b	Air Cooled Condenser	Condenser Duty, MMBtu/hr	N/A	N/A	N/A	0.70	N/A	1,000 – 3,000
8.4	Steam Piping	HP BFW Flow Rate, lb/hr	0.70					1,960,000 – 5,600,000
8.9	TG Foundations	Turbine Capacity, MW	0.71					600 – 800

Exhibit 2-10 Scaling parameters and exponents for categories 1-5: "Cooling Water System"

Account Number	Item Description	Parameter	Exponent					Range
	Category	1-5	1	2	3	4	5	1-5
9	COOLING WATER SYSTEM							
9.1	Cooling Towers	Cooling Tower Duty, MMBtu/hr	0.74					1000 – 6,000
9.2	Circulating Water Pumps	Circulating Water Flow Rate, gpm	0.86	0.73	0.73	0.86	0.73	115,000 – 550,000
9.3	Circ. Water System Auxiliaries	Circulating Water Flow Rate, gpm	0.63					115,000 – 550,000
9.4	Circ. Water Piping	Circulating Water Flow Rate, gpm	0.63					115,000 – 550,000
9.5	Make-up Water System	Raw Water Makeup, gpm	0.64	0.64	0.64[1]	0.64	0.64	2,000 – 11,200
9.6	Component Cooling Water System	Circulating Water Flow Rate, gpm	0.63					115,000 – 550,000
9.9	Circ. Water System Foundations	Circulating Water Flow Rate, gpm	0.58					115,000 – 550,000

Exhibit 2-11 Scaling parameters and exponents for categories 1-5: "Ash and Spent Sorbent Handling System"

Account Number	Item Description	Parameter	Exponent					Range
	Category	1-5	1	2	3	4	5	1-5
10	ASH/SPENT SORBENT HANDLING SYSTEM							
10.6	Ash Storage Silos	Total Ash Flow, lb/hr	0.56					10 – 100
10.7	Ash Transport & Feed Equipment	Total Ash Flow, lb/hr	0.56					10 – 100
10.9	Ash/Spent Sorbent Foundation	Total Ash Flow, lb/hr	0.56					10 – 100

[1] The exponent 0.82 should be used with ultra-supercritical plants.

Exhibit 2-12 Scaling parameters and exponents for categories 1-5: "Accessory Electric Plant"

Account Number	Item Description	Parameter	Exponent [Coefficient]					Range
Category		1-5	1	2	3	4	5	1-5
11	ACCESSORY ELECTRIC PLANT							
11.1	Generator Equipment	Turbine Capacity, MW	0.57					600 – 800
11.2	Station Service Equipment	Auxiliary Load, kW	0.43					28,300 – 272,000
11.3	Switchgear & Motor Control	Auxiliary Load, kW	0.43					28,300 – 272,000
11.4	Conduit & Cable Tray	Auxiliary Load, kW	0.43					28,300 – 272,000
11.5	Wire & Cable	Auxiliary Load, kW	0.43					28,300 – 272,000
11.6	Protective Equipment	Auxiliary Load, kW	0.00					28,300 – 272,000
11.7	Standby Equipment	Turbine Capacity, MW	0.46					588 – 835
11.8	Main Power Transformers	STG Rating, MVA	0.46 [418.03]	0.46 [418.03]	0.46 [418.03]	0.48	2.11	10 – 1000
11.9	Electrical Foundations	Turbine Capacity, MW	0.69					600 – 800

Exhibit 2-13 Scaling parameters and exponents for categories 1-5: "Instrumentation and Control"

Account Number	Item Description	Parameter	Exponent [Coefficient]					Range
Category		1-5	1	2	3	4	5	1-5
12	INSTRUMENTATION & CONTROL							
12.6	Control Boards, Panels & Racks	Auxiliary Load, kW	0.13					28,300 – 272,000
12.7	Computer Accessories	Auxiliary Load, kW	0.13					28,300 – 272,000
12.8	Instrument Wiring & Tubing	Auxiliary Load, kW	0.13					28,300 – 272,000
12.9	Other I & C Equipment	Auxiliary Load, kW	0.13					28,300 – 272,000

Exhibit 2-14 Scaling parameters and exponents for categories 1-5: "Improvements to Site"

Account Number	Item Description	Parameter	Exponent					Range
	Category	1-5	1	2	3	4	5	1-5
13	IMPROVEMENTS TO SITE							
13.1	Site Preparation	BEC (Minus Acts. 13 and 14)	0.20					735,000 – 1,630,000
13.2	Site Improvements	BEC (Minus Acts. 13 and 14)	0.20					735,000 – 1,630,000
13.3	Site Facilities	BEC (Minus Acts. 13 and 14)	0.20					735,000 – 1,630,000

Exhibit 2-15 Scaling parameters and exponents for categories 1-5: "Buildings and Structures"

Account Number	Item Description	Parameter	Exponent					Range
	Category	1-5	1	2	3	4	5	1-5
14	BUILDINGS & STRUCTURES							
14.1	Boiler Building	BEC (Minus Acts. 13 and 14)	0.09					735,000 – 1,630,000
14.2	Turbine Building	BEC (Minus Acts. 13 and 14)	0.12					735,000 – 1,630,000
14.3	Administration Building	BEC (Minus Acts. 13 and 14)	0.10					735,000 – 1,630,000
14.4	Circulation Water Pumphouse	Circulating Water Flow Rate, gpm	0.60					115,000 – 550,000
14.5	Water Treatment Buildings	Raw Water Makeup, gpm	0.65					2,000 – 11,200
14.6	Machine Shop	BEC (Minus Acts. 13 and 14)	0.10					735,000 – 1,630,000
14.7	Warehouse	BEC (Minus Acts. 13 and 14)	0.10					735,000 – 1,630,000
14.8	Other Buildings & Structures	BEC (Minus Acts. 13 and 14)	0.10					735,000 – 1,630,000
14.9	Waste Treating Building & Structures	Raw Water Makeup, gpm	0.07					2,000 – 11,200

2.2 IGCC

Exhibit 2-16 provides the category matrix for IGCC categories.

Exhibit 2-16 Category matrix: IGCC

Category	Technologies
6	Single-stage, dry-feed, oxygen-blown, down-flow gasifier with and without CO_2 capture, PRB and ND Lignite coals
7	Two-stage, slurry-feed, oxygen-blown gasifier with and without CO_2 capture, PRB coal
	Single-stage, slurry-feed, oxygen-blown gasifier with and without CO_2 capture, Illinois No. 6 coal
8	Single-stage, dry-feed, oxygen-blown, up-flow gasifier, with CO_2 capture, PRB coal with and without switchgrass
	Single-stage, dry-feed, oxygen-blown, up-flow gasifier with CO_2 capture, Illinois No. 6 coal with switchgrass
	Single-stage, dry-feed, oxygen-blown, up-flow gasifier, with and without CO_2 capture, PRB and ND Lignite coals
	Single-stage, dry-feed, oxygen-blown, up-flow gasifier without CO_2 capture, Illinois No. 6 coal
9	Transport gasifier, air- and oxygen-blown, with and without CO_2 capture, PRB and TX Lignite coals
	Transport gasifier, oxygen-blown with CO_2 capture, TX Lignite coal, with hybrid poplar

For IGCC categories, use Equation 4 for items that utilize a coefficient in addition to an exponent. In the "scaling parameters and exponents" tables below, the values presented within brackets [] are coefficients.

Equation 4

$$SC = \frac{RC}{RTPC} * C * SP^{Exp}$$

Exhibit 2-17 through Exhibit 2-31 contain the scaling parameters and exponents that are suitable for IGCC plants at the given ranges.

Exhibit 2-17 Scaling parameters and exponents for categories 6-9: "Fuel and Sorbent Handling"

Account Number	Item Description	Parameter	Exponent				Range
	Category	6-9	6	7	8	9	6-9
1	FUEL & SORBENT HANDLING						
1.1	Coal Receive & Unload	Coal feed rate, lb/hr	0.62				18,400 – 1,750,000
1.2	Coal Stackout & Reclaim	Coal feed rate, lb/hr	0.62				18,400 – 1,750,000
1.3	Coal Conveyors & Yard Crush	Coal feed rate, lb/hr	0.62				18,400 – 1,750,000
1.4	Other Coal Handling	Coal feed rate, lb/hr	0.62				18,400 – 1,750,000
1.5	Biomass Receive & Unload	Biomass Feed, lb/hr	0.62	0.62	0.62	See Note[1]	6,000 – 934,000
1.6	Biomass Handling	Biomass Feed, lb/hr	0.62				6,000 – 934,000
1.7	Biomass Conveyors	Biomass Feed, lb/hr	0.62				6,000 – 934,000
1.8	Biomass Handling Foundations	Biomass Feed, lb/hr	0.62				6,000 – 934,000
1.9	Coal & Sorbent Handling Foundations	Coal feed rate, lb/hr	0.62				18,400 – 1,750,000

[1] Use Equation 6 with exponent 0.37 for equipment and Equation 7 with exponent 0.45 for direct labor. Values provided in $1,000 (2007$).

Exhibit 2-18 Scaling parameters and exponents for categories 6-9: "Fuel and Sorbent Prep and Feed"

Account Number	Item Description	Parameter	Exponent [Coefficient]				Range
	Category	6-9	6	7	8	9	6-9
2	FUEL & SORBENT PREP & FEED						
2.1	Coal Crushing & Drying	Coal feed rate, lb/hr	0.66				18,400 – 1,750,000
2.2	Prepared Coal Storage & Feed	Coal feed rate, lb/hr	0.66				18,400 – 1,750,000
2.3	Dry Coal Injection System/ Slurry Prep and Feed	Coal feed rate, lb/hr	0.66				18,400 – 1,750,000
2.4	Misc. Coal Prep & Feed	Coal feed rate, lb/hr	0.66	0.66	0.66	0.90	18,400 – 1,750,000
2.5	Biomass Shredding & Drying	Biomass Feed, lb/hr	0.66[1]				6,000 – 934,000
2.6	Biomass Pelletization/ Dry Biomass Injection System	Biomass Feed, lb/hr	0.66				6,000 – 934,000
2.7	Prepared Biomass Storage & Feed	Biomass Feed, lb/hr	0.66				6,000 – 934,000
2.9	Coal & Sorbent Feed Foundation	Total Feed Flow Rate, lb/hr	0.66				467,100 – 1,750,000

Equation 8

$$SC = C * \left(\frac{SP}{2000} * 24\right)^{Exp}$$

[1] For oxygen-blown transportation gasification with CO_2 capture firing TX Lignite coal with hybrid poplar co-fire, use Equation 8 with a coefficient of 7.0428 to calculate equipment costs and a coefficient of 1.3724 to calculate direct labor costs. Values are provided in $1,000 (2007$).

Exhibit 2-19 Scaling parameters and exponents for categories 6-9: "Feedwater and Miscellaneous BOP Systems"

Account Number	Item Description	Parameter	Exponent [Coefficient]				Range
	Category	6-9	6	7	8	9	6-9
3	FEEDWATER & MISC. BOP SYSTEMS						
3.1	Feedwater System	BFW (HP only), lb/hr	0.71				1,000 – 4,000
3.2	Water Makeup & Pretreating	Raw water makeup, gpm	0.71				300 – 9,000
3.3	Other Feedwater Subsystems	BFW (HP only), lb/hr	0.71				1,000 – 4,000
3.4	Service Water Systems	Raw water makeup, gpm	0.71				300 – 9,000
3.5	Other Boiler Plant Systems	Raw water makeup, gpm	0.73	0.73	0.73	0.25	300 – 9,000
3.6	FO Supply Sys & Nat Gas	Total Feed Flow Rate, lb/hr	0.00	0.24	0.24	0.00	467,000 – 1,750,000
3.7	Waste Treatment Equipment	Raw water makeup, gpm	0.71				300 – 9,000
3.8	Misc. Power Plant Equipment	Total Feed Flow Rate, lb/hr	0.66	0.24	0.24	0.06	467,000 – 1,750,000

Exhibit 2-20 Scaling parameters and exponents for categories 6-9: "Gasifier and Accessories"

Account Number	Item Description	Parameter	Exponent [Coefficient]				Range
	Category	6-9	6	7	8	9	6-9
4	GASIFIER & ACCESSORIES						
4.1	Gasifier, Syngas Cooler & Auxiliaries	SGC Duty, MMBtu/hr / Total Feed Flow Rate, lb/hr	0.00	0.77/1.19 [0.29/0.71][1]	0.53 [214.0][2]	0.31/0.64 [0.51/0.49][1]	200 – 1,000 467,000 – 1,750,000
4.3	ASU/Oxidant Compression	O_2 Production, lb/hr / MAC Power, kW	2.39/0.89 [0.09/0.91][1]	0.70/0.70 [0.50/0.50][1]	0.70/0.54 [0.80/0.20][3]	0.36/0.36[4] [0.50/0.50][1]	285,000 – 1,750,000 5,000 – 316,000
4.4	LT Heat Recovery & FG Saturation/ Scrubber & Low Temperature Cooling	Total Feed Flow Rate, lb/hr	See Note[5]	See Note[6]	See Note[6]	0.40	467,000 – 1,750,000
4.6	Flare Stack System/ Soot Recovery & SARU/ Other Gasification Equipment	Total Feed Flow Rate, lb/hr	See Note[7]	0.50	0.50	0.40	467,000 – 1,750,000
4.9	Gasification Foundations	Total Feed Flow Rate, lb/hr	0.50	0.50	0.50	0.40	467,000 – 1,750,000

Equation 10

$$SC = C_1 * RC * \left(\frac{SP_1}{RP_1}\right)^{Exp_1} + C_2 * RC * \left(\frac{SP_2}{RP_2}\right)^{Exp_2}$$

Equation 11

$$SC = \frac{RC}{RTPC} * (40{,}689 * DCF^{0.136} + 289{,}128 * DCF)$$

Equation 12

$$STPC = 10^{\left[\frac{(52.825736*\log_{10} SP^3)-(924.074743*\log_{10} SP^2)+}{(5388.117529*\log_{10} SP)-10468.642234}\right]}$$

Equation 13

$$SC = C_1 * RC_1 * SP_1^{Exp} + C_2 * RC_2 * SP_2^{Exp}$$

Where:

- STPC – Scaled total plant cost
- DCF – Dry coal feed, lb/hr

[1] Use Equation 10.
[2] Non-biomass plants with PRB or ND Lignite coal use Equation 11. Non-biomass plants with Illinois No. 6 coal use exponent 0.66 with Equation 3.
[3] Biomass plants use Equation 13, values provided in $1,000 (2007$). Non-biomass plants use Equation 10 with Exponents of 0.70/0.70 and Coefficients of 0.50/0.50.
[4] TRIG air-fired plants scale on combustion turbine extraction air flow rate, lb/hr, rather than O_2 production rate.
[5] For capture plants, the TPC is 22.0 percent of the TPC of the "Gasifier, Syngas Cooler &Auxiliaries." For non-capture plants, the TPC is 23.0 percent.
[6] For capture plants, the TPC is 20.6 percent of the TPC of the "Gasifier, Syngas Cooler &Auxiliaries." For non-capture plants with PRB or ND Lignite coals, the TPC is 10.7 percent. For non-capture plants with Illinois No. 6 coal, use exponent of 0.23 with Equation 3.
[7] Use Equation 12.

Exhibit 2-21 Scaling parameters and exponents for categories 6-9: "Gas Cleanup and Piping"

Account Number	Item Description	Parameter	Exponent [Coefficient]				Range
	Category	6-9	6	7	8	9	6-9
5	GAS CLEANUP & PIPING						
5A.1	Sulfinol/Selexol (Single and Double)/MDEA-LT	Gas flow to AGR, acfm	0.85	0.79	0.79	0.95	6,000 – 30,500
5A.2	Elemental Sulfur Plant	Sulfur Production, lb/hr	0.67	0.67	0.58 [131.42][1]	0.67	300 – 43,900
5A.3	Mercury Removal	Hg bed carbon fill, ft^3	0.69 [11.05]	See Note[2]	0.034 [1.461][3]	0.70	2,000 – 35,100
5A.4	Shift Reactors/ COS Hydrolysis	WGS Catalyst volume, ft^3/ COS Catalyst volume, ft^3	0.12	0.80	0.59/0.78	0.75	2,000 – 10,600 9,000 – 25,500
5A.5	Blowback Gas Systems	Candle filter flow rate, acfm	N/A	0.30	0.75[4]	0.41	2,000 – 96,000
5A.6	Fuel Gas Piping	Fuel gas flow, lb/hr	0.7224 [2.282]	0.72	0.78 [1.87][5]	0.58	185,000 – 2,490,000
5A.9	HGCU Foundations	Sulfur Production, lb/hr	0.79	0.79	0.52[6]	0.79	300 – 43,900

[1] Non-biomass plants use the exponent 0.67 and coefficient 61.981.
[2] Use exponent 1.57 with PRB coal, use exponent 1.64 with Illinois No. 6 coal without CO_2 capture, and use exponent 1.59 with Illinois No. 6 coal with CO_2 capture. The coefficient 0.0141 is used with all plants.
[3] Non-biomass plants with Illinois No. 6 coal, use Equation 3 with an exponent of 0.60. All other non-biomass plants use the coefficient of 0.0141 and exponent of 1.5742.
[4] Non-biomass plants use the exponent of 0.30.
[5] Non-biomass plants use the coefficient 2.282 and exponent 0.7224.
[6] Non-biomass plants use the exponent of 0.79.

Exhibit 2-22 Scaling parameters and exponents for categories 6-9: "CO_2 Compression"

Account Number	Item Description	Parameter	Exponent				Range
	Category	6-9	6	7	8	9	6-9
5B	CO_2 COMPRESSION						
5B.2	CO_2 Compression & Drying	Compressor Power, kW	0.63	0.88	{0.88}[1]	0.67	28,300 – 43,500 1,000,000 – 2,200,000

Exhibit 2-23 Scaling parameters and exponents for categories 6-9: "Combustion Turbine and Accessories"

Account Number	Item Description	Parameter	Exponent				Range
	Category	6-9	6	7	8	9	6-9
6	COMBUSTION TURBINE/ACCESSORIES						
6.1	Combustion Turbine Generator	Fuel gas flow, lb/hr	0.00				185,000 – 2,490,000
6.9	Combustion Turbine Foundations	Fuel gas flow, lb/hr	0.00				185,000 – 2,490,000

[1] Biomass plants use the exponent 0.79 with the scaling parameter "CO_2 Captured, lb/hr."

Exhibit 2-24 Scaling parameters and exponents for categories 6-9: "HRSG, Ducting, and Stack"

Account Number	Item Description	Parameter	Exponent				Range
Category		6-9	6	7	8	9	6-9
7	HRSG, DUCTING & STACK						
7.1	Heat Recovery Steam Generator	HRSG duty, MMBtu/hr	0.70				600 – 5,000
7.3	Ductwork	volumetric flow to stack, acfm	0.70	0.70	0.70	0.57	1,010,000 – 2,810,000
7.4	Stack	volumetric flow to stack, acfm	0.70				1,010,000 – 2,810,000
7.9	HRSG, Duct & Stack Foundations	volumetric flow to stack, acfm	0.70	0.70	0.70	0.67	1,010,000 – 2,810,000

Exhibit 2-25 Scaling parameters and exponents for categories 6-9: "Steam Turbine Generator"

Account Number	Item Description	Parameter	Exponent [Coefficient]				Range
Category		6-9	6	7	8	9	6-9
8	STEAM TURBINE GENERATOR						
8.1	Steam TG & Accessories	Turbine capacity, kW	0.70				195,000 – 371,000
8.2	Turbine Plant Auxiliaries	Turbine capacity, kW	0.72				195,000 – 371,000
8.3a	Condenser & Auxiliaries	Condenser duty, MMBtu/hr	0.71	0.71	0.70 [52.90][1]	0.71	500 – 2,000
8.3b	Air Cooled Condenser	BFW (HP only), lb/hr {Condenser Duty, MMBtu/hr}	0.36	0.73	{0.70}	1.14	1,000 – 4,000 500 – 2,000
8.4	Steam Piping	BFW (HP only), lb/hr	0.72	0.72	0.63 [122.80][2]	0.72	1,000 – 4,000
8.9	TG Foundations	Turbine capacity, kW	0.72				195,000 – 371,000

[1] Non-biomass plants use a coefficient of 45.921 and exponent of 0.7.

[2] Non-biomass plants with PRB or ND Lignite coal use the exponent 0.7018 and coefficient 71.1. Non-biomass plants with Illinois No. 6 coal use the exponent 0.70 with Equation 3.

Exhibit 2-26 Scaling parameters and exponents for categories 6-9: "Cooling Water System"

Account Number	Item Description	Parameter	Exponent [Coefficient]				Range
	Category	6-9	6	7	8	9	6-9
9	COOLING WATER SYSTEM						
9.1	Cooling Towers	Cooling tower duty, MMBtu/hr	0.90	0.72	0.72	0.72	1,000 – 4,000
9.2	Circulating Water Pumps	Circ. water flow rate, gpm	0.72	0.72	0.69 [0.54][1]	0.72	92,600 – 330,000
9.3	Circ. Water System Auxiliaries	Circ. water flow rate, gpm	0.64				92,600 – 330,000
9.4	Circ. Water Piping	Circ. water flow rate, gpm	0.606 [6.185][2]				92,600 – 330,000
9.5	Make-up Water System	Raw water makeup, gpm	0.60				300 – 9,000
9.6	Component Cooling Water System	Circ. water flow rate, gpm	0.64				92,600 – 330,000
9.9	Circ. Water System Foundations	Circ. water flow rate, gpm	0.59				92,600 – 330,000

Exhibit 2-27 Scaling parameters and exponents for categories 6-9: "Ash and Spent Sorbent Handling System"

Account Number	Item Description	Parameter	Exponent [Coefficient]				Range
	Category	6-9	6	7	8	9	6-9
10	ASH/SPENT SORBENT HANDLING SYSTEM						
10.1	Slag Dewatering & Cooling	Slag production, lb/hr	0.64				7,000 – 351,000
10.6	Ash Storage Silos	Slag production, lb/hr	0.55				7,000 – 351,000
10.7	Ash Transport & Feed Equipment	Slag production, lb/hr	0.55				7,000 – 351,000
10.8	Misc. Ash Handling Equipment	Slag production, lb/hr	0.55				7,000 – 351,000
10.9	Ash/Spent Sorbent Foundation	Slag production, lb/hr	0.55				7,000 – 351,000

[1] Non-biomass plants use the coefficient 0.6273 and exponent 0.6714.
[2] Non-biomass plants use the exponent 0.6085 and coefficient 6.0862.

Exhibit 2-28 Scaling parameters and exponents for categories 6-9: "Accessory Electric Plant"

Account Number	Item Description	Parameter	Exponent				Range
	Category	6-9	6	7	8	9	6-9
11	ACCESSORY ELECTRIC PLANT						
11.1	Generator Equipment	Turbine capacity, kW	0.54				195,000 – 371,000
11.2	Station Service Equipment	Auxiliary load, kW	0.45				107,000 – 423,000
11.3	Switchgear & Motor Control	Auxiliary load, kW	0.45				107,000 – 423,000
11.4	Conduit & Cable Tray	Auxiliary load, kW	0.45				107,000 – 423,000
11.5	Wire & Cable	Auxiliary load, kW	0.45				107,000 – 423,000
11.6	Protective Equipment	Auxiliary load, kW	0.00	0.00	0.00	0.65	107,000 – 423,000
11.7	Standby Equipment	Total Gross Output, kW	0.48	0.48	0.48	0.00	621,000 – 835,000
11.8	Main Power Transformers	Total Gross Output, kW	0.71	0.71	0.71	0.00	621,000 – 835,000
11.9	Electrical Foundations	Total Gross Output, kW	0.70	0.70	0.70	0.00	621,000 – 835,000

Exhibit 2-29 Scaling parameters and exponents for categories 6-9: "Instrumentation and Control"

Account Number	Item Description	Parameter	Exponent				Range
	Category	6-9	6	7	8	9	6-9
12	INSTRUMENTATION & CONTROL						
12.4	Other Major Component Control	Auxiliary load, kW	0.24	0.13	0.13	0.24	107,000 – 423,000
12.6	Control Boards, Panels & Racks	Auxiliary load, kW	0.24	0.13	0.13	0.24	107,000 – 423,000
12.7	Computer & Accessories	Auxiliary load, kW	0.24	0.13	0.13	0.24	107,000 – 423,000
12.8	Instrument Wiring & Tubing	Auxiliary load, kW	0.24	0.13	0.13	0.24	107,000 – 423,000
12.9	Other I & C Equipment	Auxiliary load, kW	0.24	0.13	0.13	0.24	107,000 – 423,000

Exhibit 2-30 Scaling parameters and exponents for categories 6-9: "Improvements to Site"

Account Number	Item Description	Parameter	Exponent				Range
	Category	6-9	6	7	8	9	6-9
13	IMPROVEMENTS TO SITE						
13.1	Site Preparation	BEC Accts 1-12	0.34	0.08	0.08	0.34	1,040,000 – 1,680,000
13.2	Site Improvements	BEC Accts 1-12	0.33	0.08	0.08	0.33	1,040,000 – 1,680,000
13.3	Site Facilities	BEC Accts 1-12	0.34	0.08	0.08	0.34	1,040,000 – 1,680,000

Exhibit 2-31 Scaling parameters and exponents for categories 6-9: "Buildings and Structures"

Account Number	Item Description	Parameter	Exponent				Range
	Category	6-9	6	7	8	9	6-9
14	BUILDINGS & STRUCTURES						
14.1	Combustion Turbine Area	Gas Turbine Power, kWe	0.00				51,200 – 471,000
14.2	Steam Turbine Building	BEC Accts 1-12	0.17	0.17	0.17	0.45	1,040,000 – 1,680,000
14.3	Administration Building	BEC Accts 1-12	0.00	0.10	0.10	0.00	1,040,000 – 1,680,000
14.4	Circulation Water Pumphouse	Circ. water flow rate, gpm	0.01	0.46	0.46	0.46	92,600 – 330,000
14.5	Water Treatment Buildings	Raw water makeup, gpm	0.71				300 – 9,000
14.6	Machine Shop	BEC Accts 1-12	0.32	0.10	0.02	0.00	1,040,000 – 1,680,000
14.7	Warehouse	BEC Accts 1-12	0.32	0.10	0.02	0.00	1,040,000 – 1,680,000
14.8	Other Buildings & Structures	BEC Accts 1-12	0.35	0.10	0.02	0.21	1,040,000 – 1,680,000
14.9	Waste Treating Building & Str.	Raw water makeup, gpm	0.08	0.08	0.08	0.08	300 – 9,000

2.3 NGCC

Exhibit 2-32 provides the category matrix for NGCC categories.

Exhibit 2-32 Category matrix: NGCC

Category	Technologies
10	Natural gas, air-fired, with and without CO_2 capture
	Natural gas, air-fired with CO_2 capture and gas recycle

Exhibit 2-33 through Exhibit 2-43 contain the scaling parameters and exponents that are suitable for NGCC plants at the given ranges.

Exhibit 2-33 Scaling parameters and exponents for categories 6-9: "Feedwater and Miscellaneous BOP Systems"

Account Number	Item Description	Parameter	Exponent	Range
Category		10	10	10
3	FEEDWATER & MISC. BOP SYSTEMS			
3.1	Feedwater System	Feedwater flow (HP only), lb/hr	0.72	886,000 – 1,350,000
3.2	Water Makeup & Pretreating	Raw Water Withdrawal (gpm)	0.71	3,000 – 5,000
3.3	Other Feedwater Subsystems	Feedwater flow (HP only), lb/hr	0.72	886,000 – 1,350,000
3.4	Service Water Systems	Raw Water Withdrawal (gpm)	0.71	3,000 – 5,000
3.5	Other Boiler Plant Systems	Raw Water Withdrawal (gpm)	0.71	3,000 – 5,000
3.6	Natural Gas, incl. pipeline	Fuel gas flow, acfm average	0.07[1]	2,000 – 4,000
3.7	Waste Treatment Equipment	Raw Water Withdrawal (gpm)	0.71	3,000 – 5,000
3.8	Misc. Equip. (cranes, Air Compressor, etc.)	Fuel gas flow, acfm average	0.76	2,000 – 4,000

Exhibit 2-34 Scaling parameters and exponents for categories 6-9: "Gas Cleanup and Piping"

Account Number	Item Description	Parameter	Exponent	Range
Category		10	10	10
5A	GAS CLEANUP & PIPING			
5A.6	Exhaust Gas Recycle System	EGR Flowrate (lb/hr)	1.47	3,150,000 – 3,280,000

[1] As noted in the item description, this line item also includes the natural gas pipeline. The natural gas pipeline is an additive cost and would not be scaled. The pipeline cost is specific to the plant location and needs. Scaling over larger ranges will result in unrealistic costs since this has the effect of essentially increasing and decreasing the pipe length.

Exhibit 2-35 Scaling parameters and exponents for categories 6-9: "CO_2 Removal and Compression"

Account Number	Item Description	Parameter	Exponent	Range
Category		10	10	10
5B	CO_2 REMOVAL & COMPRESSION			
5B.1	CO_2 Removal System	CO_2 Flowrate (lb/hr)/ Inlet to Absorber, acfm	0.61[1]	445,000 – 689,000/ N/A[2]
5B.2	CO_2 Compression & Drying	CO_2 Flowrate (lb/hr)	0.77	445,000 – 689,000

Exhibit 2-36 Scaling parameters and exponents for categories 6-9: "Combustion Turbine and Accessories"

Account Number	Item Description	Parameter	Exponent	Range
Category		10	10	10
6	COMBUSTION TURBINE/ACCESSORIES			
6.1	Combustion Turbine Generator	Fuel Gas Flow, acfm	0.00	N/A
6.9	Combustion Turbine Foundations	Gas Turbine Power (kWe)	0.00	421,000 – 811,000

Exhibit 2-37 Scaling parameters and exponents for categories 6-9: "HRSG, Ducting, and Stack"

Account Number	Item Description	Parameter	Exponent	Range
Category		10	10	10
7	HRSG, DUCTING & STACK			
7.1	Heat Recovery Steam Generator	HRSG Duty (MMBtu/hr)	0.70	2,000 – 3,000
7.2	HRSG Accessories	HRSG Duty (MMBtu/hr)	1.40	2,000 – 3,000
7.9	HRSG, Duct & Stack Foundations	Stack flow rate, acfm	0.70[3]	2,390,000 – 2,860,000

[1] 40% of cost is applied to gas flow and the remainder is applied to CO_2 capture.
[2] Range has not yet been developed as parameter has not been implemented to date.
[3] Natural gas, air-fired with CO_2 capture and gas recycle uses an exponent of 0.47.

Exhibit 2-38 Scaling parameters and exponents for categories 6-9: "Steam Turbine Generator"

Account Number	Item Description	Parameter	Exponent	Range
	Category	10	10	10
8	STEAM TURBINE GENERATOR			
8.1	Steam TG & Accessories	Steam Turbine Power (kWe)	0.80	230,000 – 321,000
8.2	Turbine Plant Auxiliaries	Steam Turbine Power (kWe)	0.73	230,000 – 321,000
8.3	Condenser & Auxiliaries	Thermal Input (LHV) (kWth)	See Note[1]	1,100,000 – 1,710,000
8.4	Steam Piping	HRSG Duty (MMBtu/hr)	0.83	2,000 – 3,000
8.9	TG Foundations	Steam Turbine Power (kWe)	0.73	230,000 – 321,000

Exhibit 2-39 Scaling parameters and exponents for categories 6-9: "Cooling Water System"

Account Number	Item Description	Parameter	Exponent	Range
	Category	10	10	10
9	COOLING WATER SYSTEM			
9.1	Cooling Towers	Cooling Tower Duty (MMBtu/hr)	0.71	1,000 – 3,000
9.2	Circulating Water Pumps	Circulating water flow rate, gpm	0.72	125,000 – 294,000
9.3	Circ. Water System Auxiliaries	Circulating water flow rate, gpm	0.60	125,000 – 294,000
9.4	Circ. Water Piping	Circulating water flow rate, gpm	0.60	125,000 – 294,000
9.5	Make-up Water System	Raw water makeup, gpm	0.60	2,000 – 4,000
9.6	Component Cooling Water Sys.	Circulating water flow rate, gpm	0.60	125,000 – 294,000
9.9	Circ. Water System Foundations	Circulating water flow rate, gpm	0.60	125,000 – 294,000

[1] Natural gas, air-fired without CO_2 capture uses the exponent 0.43. Natural gas, air-fired with CO_2 capture uses the exponent 0.12. Natural gas, air-fired with CO_2 capture and gas recycle uses the exponent 0.29.

Exhibit 2-40 Scaling parameters and exponents for categories 6-9: "Accessory Electric Plant"

Account Number	Item Description	Parameter	Exponent	Range
	Category	10	10	10
11	ACCESSORY ELECTRIC PLANT			
11.1	Generator Equipment	Gross Total (kWe)	0.59	650,000 – 1,130,000
11.2	Station Service Equipment	Net Auxiliary Load (kWe)	0.64	50,700 – 73,500
11.3	Switchgear & Motor Control	Net Auxiliary Load (kWe)	0.64	50,700 – 73,500
11.4	Conduit & Cable Tray	Net Auxiliary Load (kWe)	0.64	50,700 – 73,500
11.5	Wire & Cable	Net Auxiliary Load (kWe)	0.64	50,700 – 73,500
11.6	Protective Equipment	Net Auxiliary Load (kWe)	1.10	50,700 – 73,500
11.7	Standby Equipment	Gross Total (kWe)	0.48	650,000 – 1,130,000
11.8	Main Power Transformers	STG output, MVA PLUS CTG output, MVA	0.70	750 – 820
11.9	Electrical Foundations	Gross Total (kWe)	0.70	650,000 – 1,130,000

Exhibit 2-41 Scaling parameters and exponents for categories 6-9: "Instrumentation and Control"

Account Number	Item Description	Parameter	Exponent	Range
	Category	10	10	10
12	INSTRUMENTATION & CONTROL			
12.4	Other Major Component Control	Net Auxiliary Load (kWe)	0.60	50,700 – 73,500
12.6	Control Boards, Panels & Racks	Net Auxiliary Load (kWe)	0.60	50,700 – 73,500
12.7	Computer & Accessories	Net Auxiliary Load (kWe)	0.60	50,700 – 73,500
12.8	Instrument Wiring & Tubing	Net Auxiliary Load (kWe)	0.60	50,700 – 73,500
12.9	Other I & C Equipment	Net Auxiliary Load (kWe)	0.60	50,700 – 73,500

Exhibit 2-42 Scaling parameters and exponents for categories 6-9: "Improvements to Site"

Account Number	Item Description	Parameter	Exponent	Range
	Category	10	10	10
13	IMPROVEMENTS TO SITE			
13.1	Site Preparation	Gross Total (kWe)	0.47	650,000 – 1,130,000
13.2	Site Improvements	Gross Total (kWe)	0.47	650,000 – 1,130,000
13.3	Site Facilities	Gross Total (kWe)	0.47	650,000 – 1,130,000

Exhibit 2-43 Scaling parameters and exponents for categories 6-9: "Buildings and Structures"

Account Number	Item Description	Parameter	Exponent	Range
	Category	10	10	10
14	BUILDINGS & STRUCTURES			
14.1	Combustion Turbine Area	Gas Turbine Power, kWe	0.53	421,000 – 811,000
14.2	Steam Turbine Building	Steam Turbine Power, kWe	0.60	230,000 – 321,000
14.3	Administration Building	Gross Total (kWe)	0.34	650,000 – 1,130,000
14.4	Circulation Water Pumphouse	Circulating water flow rate, gpm	0.60[1]	125,000 – 294,000
14.5	Water Treatment Buildings	Circulating water flow rate, gpm	0.66	125,000 – 294,000
14.6	Machine Shop	Gross Total (kWe)	0.34	650,000 – 1,130,000
14.7	Warehouse	Gross Total (kWe)	0.34	650,000 – 1,130,000
14.8	Other Buildings & Structures	Gross Total (kWe)	0.34	650,000 – 1,130,000
14.9	Waste Treating Building & Str.	Gross Total (kWe)	0.34	650,000 – 1,130,000

[1] Natural gas, air-fired without CO_2 capture uses an exponent of 0.82.

3 Revision Control

Exhibit 3-1 Revision table

Revision Number	Revision Date	Description of Change	Comments
1	February 5, 2014	Document formatted and edited	

4 References

1 National Energy Technology Laboratory (NETL). (September 2013). "Cost and Performance Baseline for Fossil Energy Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity,". DOE/NETL-2007/1281, Final Report (Original Issue Date, May 2007); Revision 2a Issue Date, September 2013. Available at http://www.netl.doe.gov/research/energy-analysis/energy-baseline-studies.

2 National Energy Technology Laboratory (NETL). (February 2013). "Greenhouse Gas Reductions in the Power Industry Using Domestic Coal and Biomass - Volume 2: PC Plants,". DOE/NETL-2012/1547,. Available at http://netl.doe.gov/research/energy-analysis/publications/details?pub=14d167f7-4020-4d88-a511-1df8506a894d.

3 National Energy Technology Laboratory (NETL). (April 2010). "Advancing Oxycombustion Technology for Bituminous Coal Power Plants: An R&D Guide". NETL/DOE-2010/1405. Available at http://www.netl.doe.gov/research/energy-analysis/publications/details?pub=58bf5a99-6e78-4258-be7c-9787f505011a.

4 National Energy Technology Laboratory (NETL). (September 2011). "Cost and Performance Baseline for Fossil Energy Plants - Volume 3: Low Rank Coal and Natural Gas to Electricity," Multiple files, DOE/NETL-2010/1399. Available at http://www.netl.doe.gov/research/energy-analysis/energy-baseline-studies.

Annex D

Referenced itemized list of auxiliary power consumption

No.	Equipment name	Power consumption (kW)	Quantity	Remarks
1	**MV Consumption**			
1)	Feed water pump	5687.5	2	
2)	Condensate pump	478.724	2	
3)	Closed cycle cooling water pump	519.148	2	
4)	PA fan	1310.638	4	
5)	FD fan	1327.66	4	
6)	ID fan	5191.49	4	
7)	Pulverizer	1308.51	6	
8)	Circulating Water Pump	3468.08	4	
9)	Absorber seawater pump A	319.14	2	
10)	Absorber seawater pump B	353.2	2	
11)	Absorber seawater pump D	419.14	2	
12)	Aeration Fan motor	521.28	2	
2	**Electrical System**			
1)	Lighting System	320	2	
2)	GUST Power Loss	1140	2	
3)	UAT Power Loss	220	2	
4)	Station Transformer No-load Power Loss	45	2	
5)	IPBD Power Loss	200	2	
6)	Non-segregated Bus Duct Power Loss	100	2	
7)	Power Cable Power Loss	30	2	
8)	LV Dry-type Transformer Power Loss	80	2	
9)	MV Switchgear Power Loss	50	2	
3	**Control System Power Consumption**	500	2	
4	**Admin & Dorm Area Consumption**	500	2	
5	**Steam Turbine System**			
1)	Exhauster for main oil tank	3.84	2	
2)	Jacking oil pump	19.2	2	
3)	EH oil supply pump	38.4	2	
4)	EH oil recirculating pump	2.816	2	
5)	Exhauster for gland seal steam cooler	9.6	2	
6)	Startup oil pump of feed water pump	3.84	2	
7)	Vacuum pump for steam chamber	115.2	2	
8)	Vacuum pump for water chamber	38.4	2	
9)	Motor of debris filter	51.2	4	
10)	LP heater drain pump	70.4	2	
11)	Electric water strainer for open cooling water	1.92	2	
12)	Condensate transfer pump	19.2	2	
6	**Boiler System**			
1)	ESP	400	2	
2)	PA Fan Oil Pump	5.632	4	
3)	FD Fan Oil Pump	5.632	4	

No.	Equipment name	Power consumption (kW)	Quantity	Remarks
4)	ID Fan Oil Pump	5.632	4	
5)	Coal feeder	15.36	6	
6)	Cleaning chain motor	1.4208	6	
7)	Lubricating oil pump motor	28.8	6	
8)	Coal pulverizer sealing fan motor	236.8	2	
9)	Preheater main motor	51.2	4	
10)	Air compressor motor	281.6	4	
11)	Refrigerated compressed air dryer	25.6	2	
12)	Micro heat regenerative air dryer	25.6	2	
13)	Fire test cooling fan	19.2	2	
7	**Hydraulic System**			
1)	Driving device for liquid controlled butterfly valve	7.68	4	
2)	Traveling screen wash pump motor	115.2	4	
3)	Traveling screen	28.16	4	
4)	Rotary filter net, washing line, electric butterfly valve	0.9216	8	
5)	Low pressure carbon dioxide storage tank refrigeration unit	5.76	3	
6)	Diesel engine firefighting water pump battery set	6.4	2	
7)	Jockey pump	9.6	1	
8)	Service water pump	22.4	1	
9)	Frequency-changing constant pressure domestic water-supply equipment	31.36	1	
8	**Chemical System**			
1)	DEMINERALIZED WATER PUMP FOR OPERATION	2.24	1	
2)	STEAM & WATER SAMPLING AND ANALYSIS DEVICE	9.6	2	
3)	CHEMICAL DOSING DEVICE	12.8	1	
9	**Ash Handling System**			
1)	FLUIDIZING BLOWER	57.6	2	
2)	ELECTRIC HEATER	76.8	2	
3)	ELECTRIC HEATER	76.8	2	
10	**FGD & SCR system**			
1)	FGD damper sealing air fan	8.96	2	
2)	FGD damper sealing air electric heater	115.2	2	
3)	Absorber seawater motor heater	4.224	6	
4)	Aeration Fan sound enclosure exhaust fan	3.84	2	
5)	Aeration Fan motor heater	1.28	2	
6)	CEMS	9.6	2	
7)	SCR system	64	2	
11	**HVAC System**			
1)	Air-cooled Screw Chiller for central control building	235.52	2	

No.	Equipment name	Power consumption (kW)	Quantity	Remarks
2)	Centrifugal Chilled Water Pump for central control building	29.6	2	
3)	Air Handling Unit A for central control building	72	2	
4)	Vertical Type Air Handling unit for central control building	6.4	2	
5)	Ceiling Type Air Handling unit for central control building	1.2	1	
6)	Thermal-static & Humidity -static Packaged Air Conditioners for central control building	18.96	1	
7)	Axial Fan for central control building	0.192	2	
8)	Axial Fan for central control building	0.072	1	
9)	Axial Fan for central control building	0.06	3	
10)	Explosion-proof Axial Fan for Turbine house	66	30	
11)	Explosion-proof Axial Fan for Turbine house	4.8	4	
12)	Vertical Type Air-cooled Cooling Type Packaged Air Conditioner for Turbine house	25.44	6	
13)	Ceiling Type Air-cooled Cooling Type Packaged Air Conditioner for Turbine house	29.28	4	
14)	Ceiling Type Air-cooled Cooling Type Packaged Air Conditioner for Turbine house	11.2	2	
12	**Others**	200	1	
IN ALL		**26936**		For two (2) units

Note: The above power consumption data may be adjusted a little after the procuring of the equipments.