



Kot Addu Power Company Limited

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Lahore 54660, Pakistan
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Ref: KAPCO/CEO/2024/504
June 14, 2024

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The Registrar
National Electrical Power Regulatory Authority
NEPRA Tower, Attaturk Avenue (East)
G-5/1, Islamabad, Pakistan

SUBJECT: APPLICATION FOR GENERATION LICENSE EXTENSION PROPOSED FOR GENERATION LICENSE NO. IPGL/020/2004 RELATING TO 1600MW (GROSS) KAPCO COMPLEX LOCATED AT KOT ADDU DISTRICT MUZAFFARGRAH, PUNJAB, PAKISTAN

Dear Sir,

- Pursuant to the applicable laws of Pakistan, including the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997 and the rules and regulations made thereunder (including regulation 10(2) of the National Electric Power Regulatory Authority Licensing (Application, Modification, Extension and Cancellation) Procedure Regulations 2021 and the National Electric Power Regulatory Authority Licensing (Generation) Rules, 2000) we, KOT ADDU POWER COMPANY LIMITED (the "Company"), submit before the National Electric Power Regulatory Authority (the "Authority") an application for generation license extension (together with the documents annexed thereto) (the "Generation License Extension Application") for the extension of the Licensee's Generation License No. IPGL/020/2004 read with its extension dated September 08, 2022 (the "Generation License").
- The Generation License Extension Application (including its annexures) are being submitted together with:
 - As the application fee, amounting to PKR 2,526,048/- (Pakistani Rupees Two Million Five Hundred Twenty-Six Thousand Forty-Eight only net of withholding tax @ 4%) has been transferred in Askari Bank account of the Authority from Habib Bank Limited. Reference number of transaction is 6131420000613. Bank statement is attached as evidence of payment, for a licensee proposed extension of the Generation License (as communicated to us by the Authority)
 - a certified extract of the resolutions of the board of directors of the Company dated June 12, 2024; and
 - an affidavit of Mr. Aftab Mahmood Butt, Chief Executive Officer of the Company.

Forwarded please
☒ For nec. Action ☐ For Information

<input checked="" type="checkbox"/> DG (Lic.)	<input type="checkbox"/> DG (Admin/HR)
<input checked="" type="checkbox"/> DG (M&E)	<input type="checkbox"/> DG (CAD)
<input checked="" type="checkbox"/> ADG (Trf.)	<input type="checkbox"/> DG (ATC)
<input checked="" type="checkbox"/> Dir. (Tech.)	<input type="checkbox"/> ADG (Fin.)
<input checked="" type="checkbox"/> SLA	<input type="checkbox"/> Dir. (I.T)
<input checked="" type="checkbox"/> Consult (Tech.)	<input checked="" type="checkbox"/> Consult (CTBCM)

For kind information, please.
Chairman
M (Lic.)
M (Law)

M (Tech.)
M (Trf. & Fin.)

Power Project
Kot Addu Power Complex
Kot Addu, District Muzaffargarh
Punjab - Pakistan
PABX +92 66 230 1041 - 49
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Registered Office
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Evacuee Trust Complex
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info@kapco.com.pk

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NEPRA
Licensing Department
Diary No. 6412
Date: 21-06-24

REGISTRATION OFFICE
Diary No. 6412
Date: 21-06-24

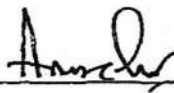
KAPCO

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3. In the light of the submissions set out in the Generation License Extension Application and the information attached to the same, the Authority is kindly requested to process the licensee proposed extension in the Generation License at the earliest.

Thanking you,

Yours faithfully,
For and on behalf of KOT ADDU POWER COMPANY LIMITED



Aftab Mahmood Butt
Chief Executive

Enclosures: As stated



HABIB BANK
حبیب بینک

Account Statement Report

Customer Name : Kot Addu Power Company Ltd
Account Number : 12424011868703
Account Title :: KOT ADU POWER COMPANY LIMITED
Account Currency : PKR
Branch Code : 1242
Branch Name : Corporate centre - Lahore
From Date : 13-JUN-2024 To 13-JUN-2024
User ID : amerkapc
Opening Balance available as of 13-JUN-2024 : -60,244,451.54
Closing Balance available as of 13-JUN-2024 : -74,754,329.94
Statement runs date and time: 6/13/2024 2:26:26 PM

Transaction Date	Value Date	Transaction Reference No	Description	Debit	Credit	Balance
13/06/2024	13/06/2024	46027991823803	CMD Services 46027991823803 58 BFT Kot Addu Po COMM MAY 2024 /B 0042-STATE LIFE, KARACHI	3,978.80		-60,248,430.34
13/06/2024	13/06/2024	46027991823803	CMD Services 46027991823803 17 LFT Kot Addu Pow COMM MAY 2024 /B 0042-STATE LIFE, KARACHI	1,809.60		-60,250,239.94
13/06/2024	13/06/2024	0000000186931083	Local Transfer 0000000186931083 0477790043503 Muhammad Nasir Orakzy	25,000.00		-60,275,239.94
13/06/2024	13/06/2024	9938361326000613	Funds Transfer 9938361326000613 BENE>RS Corporate ACC>98058171007291 STAN993836	1,000,000.00		-61,275,239.94
13/06/2024	13/06/2024	0000000186993922	Local Transfer 0000000186993922 17767900234603 RIAZ UL HASSAN	103,685.00		-61,378,924.94
13/06/2024	13/06/2024	0000000186993921	Local Transfer 0000000186993921 00427900180503 THK Associates (Pvt.) Limited	449,357.00		-61,828,281.94
13/06/2024	13/06/2024	0006121420000613	Funds Transfer 0006121420000613 BENE>KOT ADDU POWER COMPANY Limited ACC>00001420257002 STAN000612	10,400,000.00		-72,228,281.94
13/06/2024	13/06/2024	0006131420000613	Funds Transfer 0006131420000613 BENE>NEPRA ACC>00751650500481 STAN000613	2,526,048.00		-74,754,329.94

End of Statement

E-STAMP



ID : PB-LHR-E928A205577DA0E9
Type : Low Denomination
Amount : Rs 100/-



Scan for online verification

Description : AFFIDAVIT- 4
Applicant : Aftab Mahmood Butt [35202-4253519-5]
S/O : Arshad Mahmood Butt
Agent : Arsalan Rehmat [35201-0552740-3]
Address : Lahore
Issue Date : 13-Jun-2024 2:17:09 PM
Delisted On/Validity : 20-Jun-2024
Amount in Words : One Hundred Rupees Only
Reason : Affidavit
Vendor Information : Ghulam Qadir | PB-LHR-1642 | Raja Centre Gulberg

8520



نوٹ: یہ فریڈیشن تاریخ اجرا سے سات دنوں تک کے لیے قابل استعمال ہے، اس اسٹامپ کی تصدیق بذریعہ ویب سائٹ کیوں کر کرنا پڑے گی اس سے فی جا ممکن ہے۔
Type "eStamp <16 digit eStamp Number>" send to 8100

AFFIDAVIT

I, Aftab Mahmood Butt son of Arshad Mahmood Butt (late), adult do hereby solemnly affirm and state as under:

1. That I am the Chief Executive Officer of Kot Addu Power Company Limited, Lahore and I am well conversant with the affairs of the Company.
2. The contents of the Generation License Extension Application of the Company dated June 14, 2024, are true and correct to the best of my knowledge and belief.

Aftab Mahmood Butt
DEPONENT

ATTESTED
GHULAM QADIR
Notary Public Lahore

**CERTIFIED TRUE COPY OF THE EXTRACTS OF THE RESOLUTIONS PASSED AT THE
165TH MEETING OF THE BOARD OF DIRECTORS OF KOT ADDU POWER COMPANY
LIMITED HELD AT ISLAMABAD ON JUNE 12, 2024.**



CERTIFIED TRUE COPY OF THE EXTRACTS OF THE RESOLUTIONS PASSED AT THE 165TH MEETING OF THE BOARD OF DIRECTORS OF KOT ADDU POWER COMPANY LIMITED HELD AT ISLAMABAD ON JUNE 12, 2024

Page | 1

RESOLVED UNANAMOUSLY that the Company be and is hereby permitted to prepare, review, negotiate, execute, deliver, file, apply, submit and present, as required, pursuant to the applicable laws of Pakistan, including the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997 (as amended from time to time) and the rules and regulations made thereunder (including the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999, and the National Electric Power Regulatory Authority Licensing (Generation) Rules, 2000), an application (together with all documents attached thereto) before the National Electric Power Regulatory Authority ("NEPRA") for its approval of the extension of the Company's generation license No. 1 PGI/020/2004 ("Generation License Extension Application") to cater, *inter alia*, for the remaining useful life and, as a result, the PPA Term Extension, and in relation thereto, enter into and execute all required documents, make all filings, attend all hearings, provide all required information and pay all applicable fees, in each case, of any nature whatsoever.

RESOLVED UNANAMOUSLY that:

Mr. Aftab Mahmood Butt, Chief Executive be and is hereby singly authorized as representative of the Company to:

- (A) address, perform, negotiate, decide, execute, sign, implement and/or undertake, as required, for and on behalf of the Company, all matters of any nature whatsoever in relation to the Generation License Extension Application including, without limitation, to review, execute, sign, submit, file, deliver and present the Generation License Extension Application and any related documentation from time to time before and as required by NEPRA for its consideration and/or approval of the Generation License Extension Application (including any contracts, documents, powers of attorneys, affidavits, statements, letters, forms, applications, deeds, guarantees, undertakings, approvals, memorandum, amendments, letters, communications, notices, certificates, request statements and/or any other instruments / submissions of any nature whatsoever);
- (B) represent the Company in all representations, negotiations, as applicable, presentations, hearings, conferences and/or meetings of any nature whatsoever with any entity (including, but in no manner limited to NEPRA, any private parties, companies, partnerships, individuals, governmental and/or semi-governmental authorities and agencies, ministries, boards, departments, regulatory authorities and/or any other entity of any nature whatsoever) and pay the necessary fees, as required from time to time, and do all acts necessary for processing and further approval of the Generation License Extension Application by NEPRA;

A. Acsu



- (C) further sub-delegate any or all of the aforementioned powers and authorities to one or more officers of the Company or any other person or persons, singly and/or jointly; and
- (D) do all such acts, deeds and things as may be necessary for carrying out the purposes aforesaid and give full effect to the above resolutions.

Page

RESOLVED UNANAMOUSLY that Mr. Aftab Mahmood Butt, Chief Executive be and is hereby authorized to affix the Common Seal of the Company including on any document/application for the Generation License Extension Application subject to the same being done in the presence of the Company Secretary.

A. Rath

A. ANTHONY RATH
COMPANY SECRETARY

Dated: JUNE 12, 2024

BEFORE

**THE NATIONAL ELECTRIC POWER REGULATORY
AUTHORITY (NEPRA)**

**APPLICATION
FOR
GENERATION LICENSE EXTENSION**

KOT ADDU POWER COMPANY LIMITED (KAPCO)

**FOR NEPRA'S APPROVAL FOR EXTENSION OF KAPCO'S GENERATION
LICENSE NO. IPGL/020/2004**

**RELATING TO A THERMAL POWER GENERATION FACILITY OF 1600
MW (GROSS) LOCATED AT
KOT ADDU DISTRICT MUZAFFARGRAH, PUNJAB, PAKISTAN**

June 14, 2024

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SECTION 1

INTRODUCTION TO THE LICENSEE AND THE PROJECT

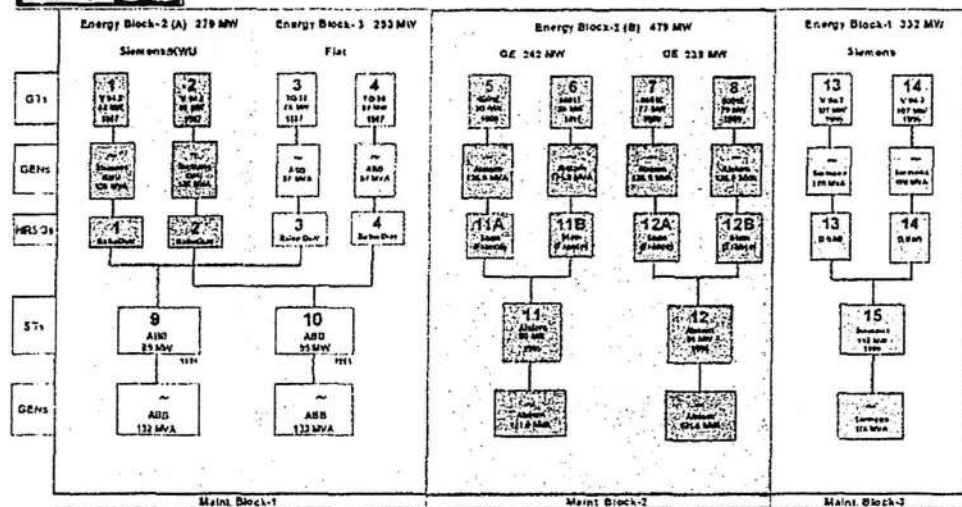
1. INTRODUCTION

1.1. THE LICENSEE

- 1.1.1. Kot Addu Power Company Limited (the "Licensee", "Company" or "KAPCO") with its corporate office at 5B/3, Gulberg III, Lahore, Punjab, Pakistan is the applicant for proposed extension (and consequently modification) to the Generation License (defined below) humbly submitted before the National Electric Power Regulatory Authority (the "Authority"). The Company was incorporated on April 25, 1996, as a public limited company under the Companies Ordinance, 1984 (which has been repealed and replaced by the Companies Act, 2017) with the objective of acquiring the Complex (defined below) from Pakistan Water and Power Development Authority ("WAPDA"). The principal activities of the Company include the ownership, operation and maintenance of the Complex.
- 1.1.2. The Privatization Commission Government of Pakistan following international competitive bidding privatized the Company on June 27, 1996. WAPDA divested thirty-six percent (36%) of its shareholding in the Company to the strategic investor (National Power) with management control.
- 1.1.3. In February 2005, the Privatization Commission (on behalf of WAPDA) sold another eighteen percent (18%) of WAPDA shareholding in the Company to the general public. On April 18, 2005, the Company was formally listed on the Pakistan Stock Exchange (formerly known as the Karachi Stock Exchange, the Lahore Stock Exchange and the Islamabad Stock Exchange).
- 1.1.4. In August 2013, the strategic investor sold its entire shareholding in the Company to local corporate entities and individuals.
- 1.1.5. The following supporting documents relating to the Licensee are attached herewith:
 - (a) **Annexure A** (*Shareholding Pattern*);
 - (b) **Annexure B** (*Memorandum and Articles of Association*); and
 - (c) **Annexure C** (*Certificate of Incorporation*).

1.2. THE POWER PLANT

- 1.2.1. KAPCO's power project (the "Complex", "Facility", "Plant" or "Project") was built by WAPDA in five (5) phases between 1985 and 1996 in District Muzaffargarh, Punjab, 90 K.M. north-west of Multan site map attached herewith as **Annexure D**. The Complex was transferred to KAPCO as per Transfer Agreement entered into between WAPDA and KAPCO as on June 27, 1996.
- 1.2.2. The salient features of the Complex are as under:
 - (a) plant name plate capacity is 1600 MW whereas guaranteed net capacity under initial dependability test is 1345 MW;
 - (b) Complex total area is 385 acres. Plant is developed on 174 acres and colony on 211 acres. There are 836 houses of different categories in the colony with recreation facilities, guest houses and hostels. Plant & colony lay out attached herewith as **Annexure E**;
 - (c) Complex comprises of ten (10) Gas Turbines, five (05) steam turbines and ten (10) heat recovery steam generators (the "HRSG"). Plant has been divided into three (03) blocks maintenance wise (Block 1, 2, 3) as well as efficiency wise in descending order Energy Block-1, 2 & 3. Plant configuration /Lay out is as below:

KAPCO**KAPCO PLANT LAYOUT-1345 MW**

- (d) the Complex is a multi-fuel gas-turbine power plant with the capability of using three (03) different fuels to generate electricity, namely: Natural gas/ RLNG (Gas), Low Sulphur Furnace Oil ("LSFO") and High Speed Diesel ("HSD"). Eight (08) of these gas turbines are capable to use all these fuels whereas two (02) gas turbines GT 3 & 4 can operate only on gas or HSD;
- (e) all machines and equipment are of European origin OEMs like GE, Siemens, Alstom and Fiat;
- (f) KAPCO has 220 KV Grid with one and half breaker scheme having six (06) transmission lines. Nine (09) units generate power at 11 kV, which is stepped up to 220 kV through nine (09) main transformers and subsequently supplied to the Power Purchaser's (defined below) grid system;
- (g) 132 KV grid has double bus bar scheme having six (06) transmission lines. Six (06) units generate power at 11 kV, which is stepped up to 132 kV;
- (h) six (06) 220 kV feeders supply power to the following areas.
- four feeders to New Multan 220 KV grid.
 - one feeder to Muzaffargarh; and
 - one feeder to Pakgen;
- (i) six (06) 132 KV feeders supply power to the following areas.
- one feeder to Khan Pur Baga Shair.
 - one feeder to Muzaffargarh;
 - one feeder to Qasba Gujrat.
 - one feeder to Shahdan Lund; and
 - two feeders to Kot Addu;
- (j) both 220 and 132 KV grids are interconnected with Auto Transformers Auto T-1, T2 & T5 (100 MVA each), 200 MVA Auto T-6 installed in April 2021 to replace T3 & T4 and to support the grid system. Single line key diagram attached herewith as Annexure F;
- (k) Complex has three (03) MW capacity black start diesel generator (the "BSDG") set to recover in case country wide blackout which has been duly demonstrated in previous blackouts. BSDG is configured with Gas Turbine 5 to 8. The Company has requested the

National Electric Power Regulator Authority (the "Authority") to approve tariff of GT-7&8 on take or pay basis in order to recover from blackout through GT-7&8 startup with BSDG. In the absence of tariff for GT-7&8 on take or pay basis, BSDG will not be available;

- (l) largest oil storage capacity in the up-country area (around 200,000 Tonnes) and also largest oil storage capacity of any plant. Fuel storage setup consists of twenty-two (22) LSFO storage tanks having storage capacity of 156 K tonnes and five (05) HSD storage tanks can store 40 million litres;
- (m) a 32 km dedicated 10-inch diameter oil pipeline from PSO's Lalpir depot to KAPCO with capacity of 3,800 Tonnes per day. The pipeline has pig facility which enables to supply LSFO & HSD through this pipeline.
- (n) Complex has twenty (20) bays decantation facility to take direct LSFO and HSD through tank Lorries. Twenty (20) tankers can be decanted at a time.
- (o) six (06) Fuel oil treatment plants (largest facility in Pakistan) to treat furnace oil for plant operation.
- (p) KAPCO receives gas through three (03) pipelines. Two 16-inch pipelines from main SNGPL network have a capacity of 400 MMSCFD and one (01) 12-inch pipeline from Dhodak has capacity of 80 MMSCFD;
- (q) raw water is sourced from two sources.
 - canal water is fed from Muzaffargarh canal from the river Indus via Taunsa Barrage; and
 - ground water through tube wells;
- (r) water taken from canal system is treated through clarifiers. In addition to demineralization plants where dissolved salts are removed, RO plant is also installed to meet plant water needs;
- (s) Complex is equipped with firefighting system: two (02) fire water storage tanks each of 700 m3 capacity are supplied from well water. Automatic CO2 system is available for GT enclosure. Automatic water deluge system is available for the main transformer;
- (t) the most important factor of KAPCO's twenty-five (25) years of excellent performance is the highly skilled work force. It has been demonstrated every year in the annual dependability tests (ADC). The Licensee has maintained the initial dependability test capacity. The Authority has allowed degradation for both capacity and heat rate to other independent power producers ("IPPs"). However, the Licensee with its excellent in-house team has proven their skills by maintaining the initial dependable capacity without asking for any degradation; and
- (u) KAPCO is one of the few combined cycle plants in the world which operates on LSFO. Two (02) other combined cycle plants in Pakistan tried to burn furnace oil but then had to switch to gas as primary fuel due to complex and difficult operation on LSFO.

1.3. THE CONTRACTUAL ARRANGEMENTS

- 1.3.1. For the purposes of the Project, the Company entered into various contractual arrangements, which included the following:

CONTRACTUAL ARRANGEMENT	DATE OF EXECUTION	PARTIES
TRANSFER AGREEMENT	June 26, 1996	KAPCO & WAPDA
SHARE PURCHASE AGREEMENT	June 26, 1996	KAPCO & WAPDA

FACILITATION AGREEMENT	June 27, 1996	KAPCO & GOP
POWER PURCHASE AGREEMENT	June 27, 1996	KAPCO & WAPDA
OIL SUPPLY AGREEMENT	June 27, 1996	KAPCO & PSO
GAS SUPPLY AGREEMENT	June 27, 1996	KAPCO & SNGPL
GOP GUARANTEE	June 27, 1996	KAPCO & GOP
SERVICES AGREEMENT	June 27, 1996	KAPCO & WAPDA
FIRST PPA AMENDMENT AGREEMENT	October 03, 2000	KAPCO & WAPDA
SECOND PPA AMENDMENT AGREEMENT	April 20, 2002	KAPCO & WAPDA
THIRD PPA AMENDMENT AGREEMENT	February 11, 2021	KAPCO & WAPDA
MASTER AGREEMENT	February 11, 2021	Petitioner & WAPDA
PPA NOVATION AGREEMENT	February 15, 2021	KAPCO, WAPDA & Central Power Purchasing Agency (Guarantee) Limited (the "Power Purchaser")
TRIPARTITE RLNG AGREEMENT	October 1, 2021	KAPCO, SNGPL & Central Power Purchasing Agency (Guarantee)

1.4. THE GENERATION LICENSE

- 1.4.1. Following enactment of Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997 (the "NEPRA Act") and the rules and regulations made thereunder, the Company applied to the Authority for procurement of a generation license for its Facility and on September 22, 2004, the Authority granted the Licensee a Generation License No. IPGL/020/2004 vide its determination bearing reference No. NEPRA/R/LAG-18/11670-71 (the "Generation License"). The Generation License was renewed by the Authority vide its determination dated September 08, 2022, bearing reference No. NEPRA/R/LAG-18/17064-71. The expiry date mentioned in face sheet of the original Generation License has been changed from September 21, 2021, to September 21, 2024. A copy of the Generation License is attached herewith as **Annexure G** for the Authority's reference.

SECTION 2

BACKGROUND TO THIS GENERATION LICENSE EXTENSION APPLICATION

2. BACKGROUND TO THIS GENERATION LICENSE EXTENSION APPLICATION

2.1. BACKGROUND

- 2.1.1. On September 22, 2004, the Authority granted the Company a Generation License. The Generation License was renewed by the Authority dated September 08, 2022. The expiry date mentioned in face sheet of the original Generation License has been changed from September 21, 2021, to September 21, 2024 which is also near to expiry and hence needs further extension.

2.2. THE PPA RENEWAL

- 2.2.1. The Power Purchase Agreement (the "PPA") contemplates a mechanism for renewal of the PPA prior to its expiry in terms of its section 4.1 (c), which states as follows:

"Renewals. Following the end of the twenty-third (23rd) Agreement Year, at the request of either Party, the Company and WAPDA agree to enter into good faith negotiations for a renewal of this Agreement for an additional term or terms of years, on terms and conditions mutually agreed to by the Parties, such term or terms of years to reflect the remaining useful lives of the various Units, and such terms and conditions similarly to reflect the extent to which some Units may have minimal or no remaining useful lives. If the Parties cannot agree to terms and conditions for the renewal of this Agreement, the Company will be permitted to contract with any other party for the sale of dependable capacity and electrical energy from the Complex and WAPDA shall deliver to the Company any necessary consents for such sale, including any consent required by Section 28 of the Electricity Act, 1910; provided, however, that WAPDA shall have no obligation to assist in such sale (other than, if then permitted by law, the transmission of electrical energy at an appropriate tariff for reasonable compensation acceptable to WAPDA) unless otherwise required by law."

- 2.2.2. At the start of the twenty-fourth (24th) year of the PPA term, the Licensee wrote to the Central Power Purchasing Agency (Guarantee) Limited ("CPPA-G") vide letter no. KAPCO/CEO/358 dated July 15, 2019, requesting CPPA-G to enter into good faith negotiation for the renewal of the PPA for another term(s) as the expected useful life of the plant is over ten (10) years. The PPA is to be renewed and to this end, KAPCO has made various correspondences with the Authority and CPPA-G. KAPCO filed tariff petition dated March 08, 2023 and subsequently NEPRA granted provisional tariff dated August 04, 2023 a copy of which is attached herewith as **Annexure H**.
- 2.2.3. NEPRA has also conducted Public Hearing dated October 03, 2023. Final Tariff determination is under process with NEPRA Authority wherein NEPRA may direct CPPA-G for PPA renewal.
- 2.2.4. After the competitive trading bilateral contracts market (the "CTBCM") is fully functional and operational from all legal, technical, commercial, financial and bankability aspects, KAPCO may consider the option to register as a participant with the market operator / CPPA-G to sell electricity: (a) to bulk power consumers; (b) dispatch as a merchant plant; or (c) provide ancillary services to system operator.

SECTION 3

**MERITS OF THE PROJECT AND JUSTIFICATION FOR PROPOSED GENERATION
LICENSE EXTENSION**

3. MERITS OF THE PROJECT AND JUSTIFICATION FOR PROPOSED GENERATION LICENSE EXTENSION

3.1 A STATEMENT OF THE REASONS IN SUPPORT OF THE PROPOSED GENERATION LICENSE EXTENSION

Without in any manner limiting the submissions made in other sections of this Generation License Extension Application (which shall stand deemed incorporated in this Section 3 for the benefit of the Authority), it is re-emphasized that:

- 3.1.1. The Licensee has operated the Facility for over two and a half decades. In this period, the Petitioner has generated, on average, around 6,260 GWh of electric power per annum. Throughout its operations, the Company has successfully met its obligations under the Original PPA. Whilst complying with a strict maintenance regime, the Facility still has a remaining useful life of over ten (10) years. This is also evident from the KAPCO Plant's remaining useful life assessment study report (the "RULA Study Report") carried out by an independent renowned consultant, M/s Ramboll UK.
- 3.1.2. The system operator has submitted updated indicative generation capacity expansion plan (the "IGCEP") IGCEP 2024-34 wherein KAPCO has been retained in the system till June 2027 as per system requirement. It is also pertinent to note that the National Transmission and Despatch Company Limited (the "NTDC") submitted the IGCEP 2022-2031 (duly approved by its board of directors), to the Authority which was approved by the Authority on February 01, 2023. As per the approved IGCEP 2022-2031, it has been documented that a minimum of 500 MW dispatch is required from the Facility till 2026 (a copy of relevant page is attached herewith as **Annexure I**). A copy of relevant page of IGCEP 2024-34 is also attached herewith as **Annexure J**). The proposed extension of the Generation License aims to ensure that the term of the Generation License caters to:
 - (a) the IGCEP requirement;
 - (b) the remaining useful life of the Facility; and
 - (c) the participation in the CTBCM subject to the CTBCM being fully operational and functional, and bankable, in all legal, technical, financial, commercial and other aspects,such that the validity of the Generation License is extended up to the Proposed Generation License Expiry Date (defined below) (the "**Proposed Generation License Extension**").
- 3.1.3. The Licensee, as part of performance of its obligations under the PPA has a very significant role in supply of power to the Multan Electric Power Company local region of Multan, Muzaffargarh, DG Khan, Layyah Districts through 220 KV and 132 KV feeders emanating from KAPCO.
- 3.1.4. The Licensee's strengths are, its strategic location, technology, flexibility of fuel, storage capacity of fuel, gas infrastructure, fuel infrastructure and power supply at different voltage levels.
- 3.1.5. As mentioned in Section 1 that the Plant of the Licensee is located at the center of the country and close to load center. In case of gas shortage for power sector, KAPCO has capability to support the system due to its flexibility and huge storage capacity of fuel. KAPCO off take all the surplus LSFO available at Attock Oil Refinery which enables them to operate their refinery smoothly.
- 3.1.6. GM (System Operation) NPCC vide their letter no 7040-45/GM (SO)/NPCC/DDPC-1/CPPAG dated May 22, 2024 (attached herewith as **Annexure K**) to Chief Financial Officer (CPPA-G) emphasizing the importance of KAPCO to ensure system stability and reliability. Earlier, NPCC has highlighted KAPCO significance for its strategic location, multifuel capability and ancillary services. System operator has placed KAPCO under the category of critically required.
- 3.1.7. Licensee's grid of 132KV and 220KV is very important for the system operator to manage in that area.
- 3.1.8. The two switchyards (132 kV /220 kV) are interconnected by 4 autotransformers having total capacity of 500 MVA. The details of these autotransformers are provided below:

- i. Autotransformer T-1&2: 2x100 MVA commissioned in 1985 (manufactured) in 1976;
 - ii. Autotransformer T-5; 100 MVA commissioned in 2006; and
 - iii. Autotransformer T-6; 200 MVA commissioned in 2021 (which replaced autotransformer T-3&T-4)
- 3.1.9. The abovementioned autotransformers are mandatory to supply power mainly from 220 kV to 132 kV grid as all 132 kV feeders from the Licensee Petitioner's Switchyard Facility have a single source of supply. However, power can also be transferred from 132 kV to 220 kV. During summer, due to increased power demand at 132 kV side, these autotransformers are overloaded and power at 132 kV is augmented through the running of KAPCO Energy Blocks EB-IIA & EB-III.
- 3.1.10. KAPCO has kept the switchyard available for the supply of electricity to the areas being served even after expiry of the PPA as per System Operator request.

3.1. USEFUL LIFE OF THE FACILITY

- 3.1.1. Rule 5(1) of the National Electric Power Regulatory Authority Licensing (Generation) Rules, 2000 (the "Rules") states as follows: *"Except where an applicant for a generation license consents to a shorter term, the term of a generation license shall be commensurate with the 'maximum expected useful life of the units comprised in a generation (facility demonstrated to the satisfaction of the Authority.)"*
- 3.1.2. To ascertain the remaining useful life, a study was awarded by Licensee to a renowned consultant M/s Ramboll of UK/Denmark. Ramboll has a team of around 15000 experts and they are placed at 300 offices in 35 countries. The Ramboll's brochure is attached herewith as **Annexure L**.
- 3.1.3. Ramboll has conducted detailed analysis of the overhauling / inspection and test reports by OEMs and other reports based on tests conducted by third party consultants. Based on their worldwide experience on different technologies, they presented their comprehensive analysis in the RULA Study Report, which is attached herewith as **Annexure M**.
- 3.1.4. For the Authority's benefit and reference, without in any way limiting the comprehensive analysis presented in the RULA Study Report, part of section 8 (Conclusion & Recommendation) is set out below:

"Operating life before retirement of CCGTs has been observed 40-50 years around the World. This study has assumed a 40-year extended operating life based on a nominal 8,000 operating hours per year, which equates to lifetime operating hours of 320,000. The operating hours of the Units at KAPCO range between 94,000 to 180,000 indicating that the remaining life of the KAPCO units could be in the range 17-28 years, thus demonstrating that a life extension of 10 years being considered by KAPCO should be achievable with resulting good reliability and performance."

- 3.1.5. It is preliminarily noted that the Ramboll has concluded, based on its extensive analysis (as contained in the RULA Study Report), that the overall condition of Complex is 'Good' and the expected remaining life is more than ten (10) years. In view of the RULA Study Report and the conclusions asserted by the same in the RULA Study Report, the Licensee submits to the Authority that in view of the afore-stated criteria laid out by rule 5(1) of the Rules and for the purposes of conclusively evidencing compliance with the same this Generation License Extension Application primarily aims to extend the term of its Generation License so as to match it with the remaining useful life of the Facility i.e., September 21, 2031 (the "Proposed Generation License Expiry Date").
- 3.1.6. The Authority's approval of the Proposed Generation License Extension and the subsequent implementation by CPPA-G and the Licensee of the PPA term extension will ensure continued supply of reliable electricity to the consumers of CPPA-G. Alternatively, the Licensee will provide reliable and cheap power to other entities / bulk power consumers under CTBCM regime.

3.2. UPGRADES AND MODIFICATIONS

UPGRADES AND MODIFICATIONS as detailed below:

Gas Turbines

- (a) gas Turbine GT-1 & 2: The third and fourth stage disc and rear hollow shafts were replaced and new, modified, blades and vanes were installed to these rows. Row 4 blades were of the latest free standing blade design;
- (b) gas Turbine GT-5~8: Stage 1, 2 & 3 buckets, nozzles & shrouds replaced with the latest design having improved material & better rupture strength. Honeycomb seals were installed; and
- (c) gas Turbine GT-13 & 14: Si3D upgradation was carried out and Blades and Vanes of Stages 1 & 2 replaced with new design.

3.3.2. Steam Turbines

On STG-10, Installed upgraded 1st stage rotating blades and Installation of new LP turbine erosion protection rings of last 3 stages.

3.3.3. Generators

- (a) GT-7 and GT8 Replacement of Insulation under Retaining Rings of Generator Rotors during 2015;
- (b) GT-8 Full Stator Rewinding of Generator during 2015;
- (c) STG-11 Full Stator Rewinding of Steam Turbine Generator with new set of bars during 2017; and
- (d) STG-12 Full Stator Rewinding of Generators during 2015.

3.3.4. Control Systems

- (a) GT-1 ISKAMATIC obsolete control system replaced with Siemens SPPA T3000 DCS and obsolete analogue type SFC / SEE system replaced with GE (Conver-team) Version D4 during 2016;
- (b) GT-2 ISKAMATIC control system replaced with Siemens SPPA T3000 DCS and obsolete analogue type SFC / SEE system replaced with GE (Conver-team) Version D42013 during 2013;
- (c) GT-5 and GT-6 Control system upgraded to Mark VIe during the 2015 Hot Gas Path Inspections (GT-7 and GT-8 remains with Mark IV control system);
- (d) GT-13 and GT-14 Replacement of Obsolete Control System with Siemens SPPA T3000 during 2017/18;
- (e) STG-9 ABB Procontrol Decontic K obsolete control system replaced with Siemens SPPA T3000 DCS during 2016;
- (f) STG-11 and STG-12 control/protection systems replaced by a new control/ protection system CONTROSTEAM V3; and
- (g) ST-15 Steam Turbine Controls system (TELEPERM-ME) and protection system (Iskamatic) replaced by Siemens SPPA-T3000 (Release 7).

3.3.5. Other Modifications

- (a) fuel Oil Treatment Plant 6 (FOTP-6) was installed / commissioned to enhance Fuel Treatment Capacity during 2015; and
- (b) RO plant was installed, commissioned & taken in operation in order to save the chemical for water treatment.

SECTION 4

PROPOSED TEXT FOR GENERATION LICENSE EXTENSION

4. PROPOSED TEXT FOR GENERATION LICENSE EXTENSION

4.1. THE PROPOSED TEXT

- 4.1.1. In view of the matters set out in this Generation License Extension Application, including, without limitation, to ensure that the term of the Generation License caters to ensure its term is valid until the Proposed Generation License Expiry Date, the Proposed Generation License Extension amends Article 4 of the Generation License as follows:

"(1) Pursuant to Rule 5 of the Rules, this License is granted/ modified for a further term of seven (7) years as per below schedule:

Revised Energy Block	Units	Gross Capacity	Net Capacity	
EB-I	GT: 13-14 & STG: 15	400 MW	334 MW	500 MW retained till June 2027 in the submitted ICCEP 2024-25 Page 39 annexure 'I'
EB-IIA	GT: 1 & STG: 9* with HRSG-1	150 MW	144 MW	
EB-IIA	GT: 2 & STG: 10* with HRSG-2	150 MW	145 MW	
EB-IIC	GT: 5-6 & STG: 11	300 MW	228 MW	
EB-IIIB	GT: 7-8 & STG: 12	300 MW	236 MW	
EB-III	GT: 3-4, STG: 9/10*	300 MW	258 MW	
Complex		1600 MW	1345 MW	

SECTION 5

**A STATEMENT OF IMPACT ON THE QUALITY OF SERVICE AND PERFORMANCE BY
THE LICENSEE OF ITS OBLIGATIONS UNDER THE GENERATION LICENSE**

5. A STATEMENT OF IMPACT ON THE QUALITY OF SERVICE AND PERFORMANCE BY THE LICENSEE OF ITS OBLIGATIONS UNDER THE GENERATION LICENSE

5.1.1. The Licensee confirms that the Licensee's quality of service and its performance under the Generation License will not be affected during the period relating to the remaining useful life. The Licensee, over almost two and half decades, has been fully diligent and has dedicated itself to providing highest quality services - setting a benchmark for exceptional performance and excellence in the power generation sector of Pakistan. The Licensee aims to continue with such performance and anticipates playing a continued pivotal role providing energy security to the national grid. Complex availability, fuel mix, net output and load factor graphs are attached herewith as **Annexure N**.

5.1.2. KAPCO technical key performance indicators are given below;

Year	NOP	Plant Load Factor	Thermal Efficiency	Plant Availability
	GWh	%	%	%
2016-17	7,335	62.4	43.7	84.3
2017-18	7,437	63.3	44.0	86.0
2018-19	4,961	42.2	44.0	91.8
2019-20	3,477	29.5	44.4	88.9
2020-21	3,562	30.3	44.5	85.6
2021-22	4,980	42.4	43.4	90.0
2022-23 till PPA expiry October 24,2022	588	15.6	42.3	97.3
Last 7 Years Average	4,620	40.8	43.8	89.1

5.1. ANCILLARY SERVICES

- 5.1.1. Four (4) autotransformers having total capacity of 500 MVA are in operation. 200 MVA Auto Transformers #6 has been installed which has increased reliability of 132 KV system and quality of service to DISCOS feeders. (This addition demonstrates the Licensee's commitment towards system support that it made investment in the last years of its PPA).
- 5.1.2. KAPCO has medium-sized units and start-up timing is to meet demand for peak hours. KAPCO units have provision of partial loading, therefore, Complex can provide ancillary support to national grid in the next ten to fifteen (10-15) years. The importance of such machines will increase after installation of more renewable energy projects.
- 5.1.3. Technical limits & unit start up times are attached herewith as **Annexure O**.

5.2. ENVIRONMENT MANAGEMENT SYSTEM

- 5.2.1. KAPCO has developed well established 'Policy Guidelines and Procedures Integrated Management System' (IMS certificates attached herewith as **Annexure P** for Quality, Health & Safety and Environment.)
- 5.2.2. Historically till PPA expiry, KAPCO has accredited and complying standard ISO 14001:2015 Environmental Management System. Environment performance monitoring has been conducted

on regular basis by a certified independent consultant of the environmental protection agency (EPA) of Punjab, in compliance with the Pakistan Environment Protection Act (PEPA), 1997 and Punjab Environment Protection Agency standards.

- 5.2.3. Environment monitoring at the Complex includes, monitoring of air, water and noise emissions generated from operations of gas turbines, steam turbines, boilers, fuel oil treatment plants etc.
- 5.2.4. Report submitted to Environment Protection Agency Punjab (EPA Punjab) as per statutory requirement is in compliance to the requirements, attached herewith as **Annexure Q**.
- 5.2.5. In acknowledgement to accomplishment achieved for environment protection, KAPCO has received "*Certificate of Appreciation from National Forum for Environment and Health*" in 2023, which is attached herewith as **Annexure R**.

5.3. HUMAN RESOURCE

- 5.3.1. The highly skilled human resource is one of its key strengths of KAPCO which gives it a competitive advantage. One of the reasons behind this high skill set is the continuous learning culture at KAPCO, which provides the individuals with a variety of learning opportunities throughout the year. These opportunities range from self-paced learning, like book reading from a variety of books available at the OD Book club to online training programs. Classroom and training ranges from in-house training sessions to experiential learning programs being conducted in the wilderness to ensure a deeper level of learning associated with such programs.
- 5.3.2. KAPCO takes keen interest in the development of its human resource using a blended learning approach, using face to face as well as an online program. The training encompasses both functional as well as soft skills training programs to address developmental needs from a holistic perspective. This approach focuses on the development of the individual as a person. As a result, the individuals experience a transformation in their lives and an up-gradation of their skill set, which positively affects the business results. KAPCO will continue to remain focused in its developmental efforts for its human resource for the future, as continuous improvement and development is the only way to thrive in a rapidly changing world.

5.4. IMPACT ON THE OBLIGATIONS OF THE LICENSEE UNDER THE LICENSE

The approval of the Proposed Generation License Extension would enable the Licensee in fulfilling its obligations under the PPA upon implementation of the PPA term extension and, beyond that, until the Proposed Generation License Expiry Date. It is highlighted that the Licensee has to-date ensured strict compliance with the terms of the Generation License and commits to continue to do the same in the future.

SECTION 6

CONCLUSION AND SUBMISSION

6. CONCLUSION AND SUBMISSION

6.1. CONCLUSION

- 6.1.1. The study carried out to assess the condition of gas turbines and steam turbines and critical electrical components covering generator, power transformer concluded with ratings good and satisfactory condition. It is pertinent to mention that the qualitative condition assessment and expected life is based on good O&M management practices based on condition monitoring, well maintained inspection, maintenance and other monitoring records, timely execution of inspection and maintenance work order, up gradations / replacement of obsolete control system, replacement of component as per preventive spares and follow instructions of troubleshooting as per OEM practices.

6.2. SUBMISSION

- 6.2.1. Pursuant to the applicable laws of Pakistan, including the NEPRA Act and the rules and regulations made thereunder (including the National Electric Power Regulatory Authority Licensing (Application, Modification, Extension and Cancellation) Procedure Regulations, 2021 (the "Regulations 2021") and the Rules: KAPCO hereby respectfully submits, for the Authority's kind and gracious consideration, this Generation License Extension Application for approval of the Proposed Generation License Extension to ensure that the Generation License is valid until the Proposed Generation License Expiry Date to reasonably utilize the useful life of the Complex.
- 6.2.2. This Generation License Extension Application is submitted with the required "generation license extension fee amounting to PKR 2,526,048 (Pakistani Rupees Two Million Five Hundred Twenty-Six Thousand Forty-Eight only net of withholding tax @ 4%) has been transferred in Askari Bank account of the Authority from Habib Bank Limited. Reference number of transaction is 6131420000613. Bank statement is attached as evidence of payment.
- 6.2.3. In light of the submissions, the relevant analysis and information contained in this Generation License Extension Application, along with the Annexures attached hereto, this Generation License Extension Application is submitted pursuant to the applicable laws of Pakistan, including the provisions of the NEPRA Act, read with enabling provisions of the rules and regulations made thereunder, including the Regulations 2021 and the Rules.

For the Authority's kind consideration and for its approval of the Proposed Generation License Extension in accordance with this Generation License Extension Application.

Respectfully submitted,

FOR AND ON BEHALF OF:

KOT ADDU POWER COMPANY LIMITED



Aftab Mahmood Butt

Chief Executive Officer and Authorized Representative

ANNEXURE A
SHAREHOLDING PATTERN

ReportID : SH0836MRG (10D08)
UserID : MANAGER

KOT ADDU POWER CO. LIMITED
Category of Shareholders
As On 31/03/2024

Page : 1
Date : 05/04/2024

Particulars	No of Folio	Balance Share	Percentage
DIRECTORS, CEO, SPOUSE & CHILDREN	8	88005	0.0088
ASSOCIATED COMPANIES	2	402563562	45.7327
BANKS, DFI & NBF	17	128035049	14.5453
INSURANCE COMPANIES	13	23154519	2.6304
MUTUAL FUNDS	12	3501753	0.3978
GENERAL PUBLIC (LOCAL)	59458	231108783	26.2546
GENERAL PUBLIC (FOREIGN)	3426	26618528	3.0240
OTHERS	189	40895350	4.6459
FOREIGN COMPANIES	9	10533206	1.1966
APPROVED FUND	24	13758473	1.5630
Company Total	83138	880253228	100.0000

ReportID : SH0830MRG(10D09)
UserID : MANAGER

KOT ADDU POWER CO. LIMITED
Pattern of Shareholding
As On 31/03/2024

Page : 1
Date : 05/04/2024

NO. OF SHAREHOLDERS	← HAVING SHARES →		SHARES HELD	PERCENTAGE
	From	To		
1627	1	100	75385	0.0086
47464	101	500	23402278	2.6588
3440	501	1000	3283821	0.3731
5508	1001	5000	15320397	1.7405
1852	5001	10000	14716080	1.6716
790	10001	15000	10138352	1.1515
482	15001	20000	8875767	1.0083
345	20001	25000	8055029	0.9151
240	25001	30000	8799230	0.7724
150	30001	35000	4945954	0.5619
128	35001	40000	4972123	0.5649
84	40001	45000	3811802	0.4103
146	45001	50000	7174772	0.8151
62	50001	55000	3262576	0.3706
70	55001	60000	4110808	0.4670
51	60001	65000	3221470	0.3680
49	65001	70000	3355397	0.3812
31	70001	75000	2273400	0.2583
29	75001	80000	2271158	0.2580
22	80001	85000	1828117	0.2075
24	85001	90000	2114462	0.2402
23	90001	95000	2132583	0.2423
107	95001	100000	10681287	1.2112
23	100001	105000	2354357	0.2675
12	105001	110000	1298887	0.1476
18	110001	115000	2043549	0.2322
26	115001	120000	3075526	0.3494
12	120001	125000	1485939	0.1688
9	125001	130000	1155000	0.1312
8	130001	135000	1060720	0.1205
10	135001	140000	1373900	0.1561
8	140001	145000	1142700	0.1298
21	145001	150000	3126833	0.3552

ReportID : SH0930MRG(10D09)
UserID : MANAGER

KOT ADDU POWER CO. LIMITED
Pattern of Shareholding
As On 31/03/2024

Page: 2
Date : 05/04/2024

NO. OF SHAREHOLDERS	← HAVING SHARES →		SHARES HELD	PERCENTAGE
	From	To		
6	150001	155000	917012	0.1042
6	155001	160000	949378	0.1079
10	160001	165000	1637715	0.1860
8	165001	170000	1342198	0.1525
1	170001	175000	171494	0.0195
6	175001	180000	1069432	0.1215
4	180001	185000	730000	0.0829
2	185001	190000	380000	0.0432
6	190001	195000	1159627	0.1318
23	195001	200000	4599981	0.5214
6	200001	205000	1003162	0.1140
3	205001	210000	822000	0.0707
2	210001	215000	426972	0.0485
2	215001	220000	433000	0.0492
4	220001	225000	892500	0.1014
4	225001	230000	914700	0.1039
3	230001	235000	702000	0.0798
5	235001	240000	1181030	0.1353
3	240001	245000	727780	0.0827
12	245001	250000	2995000	0.3402
4	250001	255000	1006195	0.1143
3	255001	260000	775037	0.0880
2	260001	265000	527000	0.0599
2	265001	270000	536788	0.0610
1	270001	275000	270700	0.0308
3	275001	280000	830907	0.0944
1	285001	290000	289500	0.0329
12	295001	300000	3590400	0.4079
1	300001	305000	304500	0.0348
2	305001	310000	616300	0.0700
3	315001	320000	951938	0.1081
2	330001	335000	688000	0.0789
2	335001	340000	680000	0.0772

portID : SH0930MRG(10D09)
userID : MANAGER

KOT ADDU POWER CO. LIMITED
Pattern of Shareholding
As On 31/03/2024

Page : 3
Date : 05/04/2024

NO. OF SHAREHOLDERS	← HAVING SHARES →		SHARES HELD	PERCENTAGE
	From	To		
1	345001	350000	350000	0.0398
1	350001	355000	355000	0.0403
1	360001	365000	363522	0.0413
1	365001	370000	366880	0.0420
2	370001	375000	747000	0.0849
1	375001	380000	380000	0.0432
3	380001	385000	1148000	0.1304
1	385001	390000	387500	0.0440
8	395001	400000	3195205	0.3630
1	400001	405000	401980	0.0457
1	405001	410000	407585	0.0463
1	410001	415000	412000	0.0468
1	425001	430000	430000	0.0488
2	445001	450000	900000	0.1022
1	450001	455000	454150	0.0516
1	455001	460000	458000	0.0521
1	470001	475000	475000	0.0540
1	480001	485000	480500	0.0546
9	495001	500000	4499000	0.5111
1	500001	505000	500285	0.0568
1	525001	530000	526284	0.0598
1	545001	550000	550000	0.0625
1	565001	570000	566493	0.0644
1	570001	575000	573000	0.0651
4	595001	600000	2399852	0.2728
2	645001	650000	1299000	0.1476
1	670001	675000	675000	0.0767
3	695001	700000	2100000	0.2388
2	700001	705000	1405800	0.1597
1	705001	710000	708500	0.0805
1	745001	750000	750000	0.0852
1	805001	810000	810000	0.0920
1	885001	890000	887500	0.1008

ReportID : SH0930MRG(10D09)

UserID : MANAGER

KOT ADDU POWER CO. LIMITED

Pattern of Shareholding

As On 31/03/2024

Page : 4

Date : 05/04/2024

NO. OF SHAREHOLDERS	←- HAVING SHARES -→		SHARES HELD	PERCENTAGE
	From	To		
1	925001	930000	926913	0.1053
1	945001	950000	950000	0.1079
1	985001	990000	989000	0.1124
3	995001	1000000	3000000	0.3408
2	1000001	1005000	2006722	0.2280
1	1010001	1015000	1011955	0.1150
1	1055001	1060000	1060000	0.1204
1	1090001	1095000	1090589	0.1239
1	1110001	1115000	1111500	0.1263
1	1130001	1135000	1135000	0.1289
1	1145001	1150000	1148530	0.1302
1	1180001	1185000	1185000	0.1323
1	1180001	1185000	1181944	0.1343
1	1195001	1200000	1200000	0.1363
1	1245001	1250000	1250000	0.1420
1	1330001	1335000	1335000	0.1517
1	1345001	1350000	1350000	0.1534
2	1385001	1370000	2736712	0.3109
1	1380001	1385000	1381266	0.1581
1	1465001	1470000	1470000	0.1670
4	1495001	1500000	6000000	0.6816
1	1510001	1515000	1515000	0.1721
1	1525001	1530000	1529250	0.1737
1	1545001	1550000	1550000	0.1761
1	1630001	1635000	1635000	0.1857
1	1775001	1780000	1776000	0.2018
1	1820001	1825000	1821684	0.2070
2	1985001	2000000	4000000	0.4544
1	3245001	3250000	3247289	0.3689
1	3975001	3980000	3978492	0.4520
1	4025001	4030000	4030000	0.4578
1	4095001	4100000	4098512	0.4656
1	4200001	4205000	4201170	0.4773

ReportID : SH0930MRG(10D09)
UserID : MANAGER

KOT ADDU POWER CO. LIMITED
Pattern of Shareholding
As On 31/03/2024

Page : 5
Date : 05/04/2024

NO. OF SHAREHOLDERS	← HAVING SHARES →		SHARES HELD	PERCENTAGE
	From	To		
1	5020001	5025000	5023266	0.5707
1	5265001	5270000	5266880	0.5993
1	5730001	5735000	5731000	0.6511
1	5800001	5805000	5804000	0.6594
1	5885001	5900000	5899711	0.6809
1	5995001	6000000	6000000	0.6816
1	6590001	6595000	6593894	0.7491
1	7045001	7050000	7046000	0.8005
1	13920001	13925000	13921900	1.5816
1	28310001	28315000	28313395	3.2165
1	43995001	44000000	44000000	4.9986
1	48250001	48255000	48252429	5.4817
1	48815001	48820000	48817302	5.5231
1	354310001	354316000	354311133	40.2510
63138		Company Total	880253228	100.0000

ANNEXURE B

MEMORANDUM AND ARTICLES OF ASSOCIATION

THE COMPANIES ORDINANCE, 1984
COMPANY LIMITED BY SHARES



KAPCO



Memorandum

and

Articles of Association

of

KOT ADDU POWER COMPANY LIMITED

The Companies Ordinance, 1984

(Company Limited by Shares)

MEMORANDUM OF ASSOCIATION

OF

KOT ADDU POWER COMPANY LIMITED

I. NAME:

The name of the Company is Kot Addu Power Company Limited.

II. REGISTERED OFFICE:

The registered office of the Company will be situated in the Islamabad Capital Territory.

III. OBJECTS:

The objects for which the Company is established are to undertake any or all of the following business in and outside Pakistan:

- (1) Kot Addu Power Facility. To acquire or purchase from the Pakistan Water & Power Development Authority ("WAPDA") the business, properties, assets and undertakings of WAPDA's blended fuel oil, high speed diesel and natural gas fired combined cycle power station, having a nominal generation capacity of 1650 MW, located at Kot Addu in the Punjab Province together with related facilities ("Kot Addu Power Facility") and to take over any or all of the belongings, funds, assets, rights, privileges, liabilities, obligations and contracts related to or in respect of the Kot Addu Power Facility.
- (2) Power Generation. To carry on the business of power generation, transmission and distribution.
- (3) Construction and Maintenance. To finance, design, construct, own, operate and maintain power houses and grid stations together with all

machinery, equipment and works ancillary thereto and plan, survey, design, supply equipment and carry out the construction of grid stations and transmission lines of all voltages and to do all such acts, deeds and things, without limitation whatsoever as may be necessary or desirable in that connection.

- (4) Electrification. To plan, survey, design, supply equipment and carry out the electrification of cities, towns, villages, gas and oil refineries, workshops, building, tube-wells, highways bridges, culverts, airports, air-terminals, sea ports, harbors and tube-well project.
- (5) Renovation and Augmentation. To carry out overall planning of electrification, augmentation and renovation of electrical systems and to design and supervise the electrification of all types of buildings and factories.

Schemes. To plan and frame schemes for irrigation, water supply and drainage, recreational use of water resources, inland navigation, flood control, prevention of water logging and reclamation of waterlogged and salted lands and to place wires, poles, wall brackets, stays, apparatus and appliances for the transmission of electricity or for the transmission of telegraphic and telephonic communications necessary for the proper execution of a scheme.

Engineering and Consultancy. To carry on the business of electrical engineers, mechanical engineers, civil engineers, electricians, contractors, consultants, agents and manufacturers of electric plant machinery, equipment and apparatus, and of generating, producing and supplying light, heat, sound and power by electricity, galvanism, magnetism or otherwise, whether for the purpose of light, heat, motive power, telephonic, telegraphic, industrial or other purposes, and generally of installing, executing, providing, working and maintaining all necessary plant, machinery, equipment, cables, wires, accumulators, lamps, exchanges, telephones and apparatus.

- (8) Technical Assistance. To render technical assistance to foreign countries in connection with power resource development and utilization and to receive assistance from foreign countries in such matters.
- (9) Workshops. To establish all sorts of workshops for manufacture and maintenance of all types of electrical equipments, tools and materials.

- (10) Dealing in Plant Equipment. To import, export, buy, sell, hire or deal in plant, machinery, equipment, cables, wires, accumulators, lamps, exchanges, telephones, fittings, furniture and apparatus of every kind with special reference to plant, machinery, equipment or apparatus connected with the producing, storage, supplying, using, regulating or measuring the supply or facilitating the use of electricity or electrical current or force.
- (11) Dealing in other Equipment. To buy, sell, import, export, hire, manufacture, deal in and turn to account plant, machinery, implements, conveniences, provisions, articles and products capable of being used in connection with the operation of or required by workmen and others employed by the company or incidentally or conveniently connected with any such business as aforesaid.
- (12) Training. To train professionals, personnel and workers, both in Pakistan and abroad, to obtain technical proficiency in various specialities connected with the business of the Company and to provide scholarships and stipends for such training.
- (13) Advertising. To adopt such means of making known the products of the Company as may seem expedient, and in particular by advertising in the press, by circulars, by purchase and exhibition of works of art or interests, by publication of books and periodicals, by granting prizes, rewards and donations.
- (14) Agents. To act as or appoint agents, sub-agents, attorneys, consultants, brokers, and contractors in connection with the business of the Company but not to act as stock-brokers or managing agents as restricted under law.
- (15) Bank Accounts. To open, close and operate banking accounts of the Company with any bank or banks and to draw, make, accept, endorse, discount, execute and issue promissory notes, bills of exchange, bills of lading, warrants, debentures and other negotiable or transferable instruments but not to act as a finance or banking company.
- (16) Securities. To issue securities, including participation term certificates and debentures and debenture stock, in consideration of any funds, moneys, accommodation received or to be received by the Company whether in cash or in specie or against any promise, guarantee, undertaking or indemnity issued to or in favour or benefit of the Company.

(17) Borrowing. To receive money on loan and borrow money in such manner as the Company shall think fit, and in particular by the issue of debentures, or debenture stocks (perpetual or otherwise) and to secure the repayment of any money borrowed, or owing mortgage, charge or lien upon all or any of the property or assets of the Company (both present and future) and also by a similar mortgage, charge or lien to secure and guarantee the performance by the Company or any other person or company of any obligation undertaken by the Company or any other person or company as the case may be, but not to act as a finance or banking company.

(18) Building. To build, construct, alter, maintain, enlarge, pull down, remove or replace, and to work, manage and control any buildings, offices, factories, mills, warehouses, shops, stores, machineries, engines, roads, ways, railways, branches or sidings, bridges, reservoirs, watercourses, wharves, electric works and other works and conveniences which may seem calculated directly or indirectly to advance the interests of the Company, and to join with any other person or company in doing any of these things.

(19) Charity. To subscribe or contribute or otherwise to assist or to guarantee money to charitable, benevolent, religious, literary, scientific, technical, national, public or any other institutions, for its objects or purposes or for any exhibition.

(20) Companies. To promote, constitute, incorporate, form, register and operate any company or companies or other legal entities anywhere for any purpose which may seem directly or indirectly calculated to benefit this Company, and/or to subscribe for, take, or otherwise acquire, and hold shares, debentures or other securities of or amalgamate or merge, into any other company having objects altogether or in part similar to those of this Company or carrying on any business capable of being conducted so as directly or indirectly to benefit this Company, but not to act as an investment company.

(21) Contracts. To enter into agreement with any individual, firm, co-operative or other society, company, corporate body, Government or local authority or other legal entity necessary or expedient for the purpose of carrying on any business of the Company.

(22) Employees' funds. To establish and maintain or procure the establishment and maintenance of any contributory or non-contributory pension or

superannuation funds for the benefit of, and give or procure the giving of donations, gratuities, pensions, allowances or emoluments to any persons who are or were at any time in the employment or service of the Company, or of any company which is a subsidiary of the Company or is allied to or associated with the Company or with any such subsidiary company, or who are or were at any time directors or officers of the Company or of any such other company as aforesaid, and the wives, widows, families and dependents of any such persons, and also to establish and subsidize and subscribe to any institutions, associations, clubs or funds calculated to be for the benefit of or to advance the interests and well being of the Company or of any such other company as aforesaid, and make payments to or towards the insurance of any such person as aforesaid and do any of the matters aforesaid, either alone or in conjunction with any such other company as aforesaid.

- (23) Other Funds. To create any depreciation fund, reserve fund, sinking fund, insurance fund, or any other special fund, whether for depreciation, or for repairing, improving, extending or maintaining any of the property of the Company.
- (24) Employment. To employ and remunerate managers and other officers, employees and servants of the Company or any person or firm or company rendering services to the Company upon such terms as the Company may determine.
- (25) Expenses. To pay out of the funds of the Company all expenses of and incidental to the formation, registration, advertisement of the Company and the issue and subscription of the share or loan capital including brokerage and/or commission for obtaining applications for or placing or guaranteeing the placing of shares or any debentures, debenture stocks and other securities of this Company and also all expenses relating to the issue of any circular or notice and the printing, stamping circulating of proxies and forms to be filled up by the members of the Company.
- (26) Foreign Branches. To open branches, register the Company and to undertake all or any of the business of the Company in any part of the world and to become a member of various associations and trade bodies whether in Pakistan or abroad.
- (27) Government Permissions. To apply for and obtain necessary consents, permissions and licenses from any Government, State, Local and other authorities for enabling the Company to carry any of its objects into effect

or for extending any of the powers of the Company or for effecting any modification of the constitution of the Company or for any other purpose which may seem expedient, and to oppose any proceedings or applications which may seem calculated, directly or indirectly to prejudice the interests of the Company, and to enter into arrangements with any Government or authorities, central, provincial, municipal, local or otherwise, public or quasi-public bodies, or with any other persons, in any place where the Company may have interests that may seem conducive to the objects of the Company or any of them and to obtain from any such Government, authorities or persons any rights, privileges and concessions which the Company may think fit to obtain, and to carry out, exercise and comply therewith.

- (28) Import and Export. To carry on all or any of the business of importers, exporters, ship owner, shipbuilders, charterer of ships and other vessels, warehousemen, wharfingers, merchants, ship and insurance brokers, carriers and forwarding agents.

- (29) Insurance. To insure the property, assets, and employees of the Company in any manner deemed fit by the Company, and to create any reserve fund, sinking fund, insurance fund or any other special fund whether for depreciation or for repairing, insuring, improving, extending or maintaining any of the property of the Company or for any other purpose conducive to the interests of the Company but not to act as an insurance company.

- (30) Investment. To invest the surplus moneys of the Company not immediately required in any manner but not to act as an investment company.


- (31) Lending. To advance money or give credit to such persons or companies and on such terms as may seem expedient and in particular to customers and others having dealings with the Company, and to guarantee the performance of any contract or obligation and the payment of money by the Company.

- (32) Other Business. To carry on any other business, whether agricultural, industrial, commercial, engineering, consultancy, construction, mining, manufacturing or trading which may seem to the Company capable of being conveniently carried on in connection with the above, calculated directly or indirectly to enhance the value of or render profitable any of the Company's property or rights and to acquire and undertake the whole

or any part of the business, property, and liabilities of any person or company carrying on or proposing to carry on any business which the Company is authorized to carry on, or possessed of property suitable for the purposes of the Company, or which can be carried on in conjunction therewith or which is capable of being conducted so as directly or indirectly to benefit the Company.

- (33) Partnerships. To enter into partnership or other joint venture or co-operation with any person or company or other legal entity, local or foreign, carrying on or engaged in any business or transaction which this Company is authorized to carry on or engage in, or otherwise assist any such person or company or legal entity.
- (34) Patents/Trademarks. To apply for, purchase, or otherwise acquire and protect and renew in any part of the world any patents, patent rights, brevets d'invention (trade marks, designs), licenses, concessions, and the like, conferring any exclusive or non-exclusive or limited right to their use, or any secret or other information as to any invention which may seem capable of being used for any of the purposes of the Company, or the acquisition of which may seem calculated directly or indirectly to benefit the Company, and to use, exercise, develop, or grant licenses in respect of, or otherwise turn to account the property, rights or information so acquired, and to expend money in experimenting upon, testing or improving any such patents, inventions or rights; and to sell any patent rights or privileges belonging to the Company or which may be acquired by it, or any interest in the same, and to grant licenses for the use and practice of the same or any of them and to let or allow to be used or otherwise deal with any inventions, patents or privileges in which the Company may be interested, and to do all such acts and things as may be deemed expedient for turning to account any inventions, patents and privileges in which the Company may be interested.
- (35) Profits/Capitalization. To receive, declare and distribute profits and to capitalize such portion of the profits of the Company as are not distributed among shareholders of the Company in the form of dividends, and as the Company may think fit, and to issue bonus shares, as fully paid up, in favor of the shareholders of the Company.
- (36) Property. To acquire, purchase, lease, rent, hire, exchange, gifts, sell, transfer, convey or otherwise dispose of any moveable or immoveable property, rights and privileges on such terms and conditions as the

Company may think necessary or convenient for the purpose of its business.

- 
- (37) Registration/Fees. To file or register any documents required to be filed or registered under law, and to pay any fees, charges, expenses, rents, taxes, duties and other dues payable in connection with the business or operation of the Company.
- (38) Regulations. To make rules or regulations not inconsistent with this Memorandum, to provide for all matters for which provision is necessary or expedient for the purpose of giving effect to the provisions of this Memorandum and the efficient conduct of the affairs of the Company.
- (39) Research and Development. To improve, manage, develop, grant rights or privileges in respect of, or otherwise deal with, all or any part of the property and rights of the Company and to establish laboratories, research and development centres to perform such research and development as the Company may deem advisable or feasible, and to expend money on experimenting upon and testing and improving or securing any process, or processes, patent or protecting any invention or inventions which the Company may acquire or propose to acquire or deal with.
- (40) Sale and Purchase. To accept, buy, sell, market, supply, transfer (including transfer of actionable claims) or deliver any and every kind of moveable property for such price and subject to such terms, conditions and warranties as the Company may think fit.
- (41) Sale of Undertaking. To sell, improve, manage, develop, exchange, lease, mortgage, enfranchise, dispose of, turn to account, or otherwise deal with, all or any part of the property, assets or undertaking of the Company for such consideration as the Company may think fit, and in particular for shares, debentures, or other securities of any other company whether or not having objects altogether or in part similar to those of this Company, and to distribute among the members in specie any property of the Company, or any proceeds of sale or disposal of any property of the Company.
- (42) Security. To accept or give security, including but not limited to promissory notes, indemnity bonds, guarantees, assignments, receipts, bailments, pledges, hypothecations, liens, mortgages and charges, against the credit extended or moneys borrowed in connection with the business of the Company.

- (43) Settlement of Disputes. To settle disputes by negotiation, conciliation, mediation, arbitration, litigation or other means and to enter into compromise with creditors, members and any other persons in respect of any difference or dispute with them.
- (44) Transportation and Communication. To carry on the business of common carriers of goods and passengers by road, rail, air, or water and also to carry on the business of designers, manufacturers, buyers, sellers, hirers, renters, agents, dealers, distributors, repairers, exporters, importers, owners, and charterers of road vehicles, aircraft and ships, and to engage in any business of communication.
- (45) Trusts. To vest any real or personal property, rights or interests acquired by or belonging to the Company in any person or company on behalf of or for the benefit of the Company, and with or without any declared trust in favor of the Company, and to undertake and execute any trust or the undertaking whereof may seem desirable, and either gratuitously or otherwise.
- (46) Underwriting/Brokerage. To underwrite the shares, or securities of any other company and to pay underwriting commission and brokerage on any shares, or securities issued by the Company.
- (47) General Power. To do all such other things as may be deemed incidental or conducive to the attainment of the above objects or any of them.

Declaration. It is hereby declared that

- (a) the word "company" in this clause except where used in reference to this Company, shall be deemed to include any partnership or other body of persons, whether corporate or unincorporated, and whether domiciled in Pakistan or elsewhere;
- (b) the objects specified in each of the paragraphs of this clause shall be regarded as independent objects, and accordingly shall in no way be limited or restricted (except where otherwise expressed in such paragraphs) by reference to or inference from the terms of any other paragraph or the name of the Company, but may be carried out in as full and ample a manner and construed in as wide a sense as if each of the said paragraphs defined the objects of a separate and distinct company;

(c) the headings used in each of the paragraphs of this clause are for convenience only and are not intended to affect the construction thereof in any way;

(d) notwithstanding anything contained in the foregoing object clauses of this Memorandum of Association, nothing herein shall be construed as empowering the Company to undertake or indulge in the business of banking, finance, leasing, investment or insurance, directly or indirectly, as restricted under law or any unlawful operations.

IV. LIABILITY:

The liability of the members is limited.

V. SHARE CAPITAL:

The share capital of the Company is Rs. 36,000,000,000.00 (Rupees thirty six billion) divided into 3,600,000,000 (three billion six hundred million) ordinary shares of Rs. 10 (Rupees ten) each with power to increase or reduce the capital and to divide the shares in the capital for the time being into several classes and to attach thereto respectively such rights, privileges or conditions may be determined by or in accordance with the regulations of the Company, and to vary, modify or abrogate any such rights, privileges or conditions in such manner as may for the time being be provided by the regulations of the Company in accordance with law provided, however, that rights as between various classes of ordinary shares, if any, as to profits, votes and other benefits shall be strictly proportionate to the paid up value of shares.

We, the several persons whose names and addresses are subscribed below, are desirous of being formed into a company in pursuance of these Memorandum of Association and we respectively agree to take the number of shares in the capital of the Company set opposite to our respective names.

Name and Surname (Present and Former) in Full (in Block Letters)	Father's, Husband's Name in Full	Nationality with any Former Nationality	Occupation	Residential Address in Full	Number of Shares taken by each Shareholder	Signature
1. KHALID JAWED	A.D. Qureshi	Pakistani	Chairman WAPDA	c/o WAPDA House Lahore	1	Sd/-
2. BASHIR AHMED ABDASI	Hafiz Nisar Ahmed	Pakistani	Member (Power) WAPDA	c/o WAPDA House Lahore	1	Sd/-
3. JAWED ASLAM CALLEA	Iqbal Ahmad Callea	Pakistani	Member (Finance) WAPDA	c/o WAPDA House Lahore	1	Sd/-
4. KHALID MOHTADULLAH	Qazi Mohdullah Khan	Pakistani	Member (Water) WAPDA	c/o WAPDA House Lahore	1	Sd/-
5. AKBAR KHAN	Mulim Shah	Pakistani	M.D. (T&G) WAPDA	c/o WAPDA House Lahore	1	Sd/-
6. JUSTICE (RETD) CH. KHALID MEHMOOD	Ch. Abdul Hamid	Pakistani	Advocate	c/o WAPDA House Lahore	1	Sd/-
7. CH. ARSHAD ZAMAN	Ch. Siker Zaman	Pakistani	G.M. Thermal WAPDA	c/o WAPDA House Lahore	1	Sd/-
Total Number of Shares					7	

Dated the 25th April 1996

Witness to above signatures
Sd/-

Ch. Mazhar Ali S/o
Ch. Diwan Ali
Khan & Piracha
No. 1, Second Floor
Block 6-13, Markaz F-6
ISLAMABAD

CERTIFIED TO BE TRUE COPY

COMPANY REGISTRAR
Company Registration Office
Islamabad.

CERTIFIED TO BE TRUE COPY

Company Registration Office Islamabad

5393
18/4/96

The Companies Ordinance, 1984
(Company Limited By Shares)
ARTICLES OF ASSOCIATION
OF
KOT ADDU POWER COMPANY LIMITED

I. PRELIMINARY

1. Table 'A' Not to Apply

The regulations in Table 'A' in the First Schedule to the Companies Ordinance, 1984 shall not apply to the Company except as reproduced herein.

Interpretation

In these Articles, unless the context or the subject matter otherwise requires:

- (a) "Affiliate" means, as to any specified person, any other person owning and controlling, owned and controlled by, or under common ownership and control with such specified person.
- (b) "Articles" means these Articles as originally framed and as from time to time altered in accordance with law.
- (c) "Board" means a meeting of the Directors duly called and constituted or as the case may be, the Directors assembled at a Board.
- (d) "Company" means Kot Addu Power Company Limited.
- (e) "Chief Executive" means the chief executive of the Company appointed from time to time by the Directors.
- (f) "Debt" means, as to the Company, any obligation for borrowed money (and any notes payable and drafts accepted representing extensions of credit whether or not representing obligations for borrowed money) which



would, in accordance with generally accepted accounting principles in Pakistan at the time of application, constitute a liability, but in any event including (i) any obligation owed for all or any part of the purchase price of property or other assets or for the cost of property or other assets constructed or of improvements thereto, other than accounts payable included in current liabilities and incurred in respect of property purchased in the ordinary course of business, (ii) any obligation secured by a Lien on, or payable out of the proceeds of, production from property even though the Company has not assumed or become liable for the payment of such obligation, (iii) any obligations that should be capitalised in respect of a lease of property that should be capitalised on the Company's balance sheet, and (iv) guarantees, endorsements and other contingent obligations (other than any endorsements of negotiable instruments for collection in the ordinary course of business) for the payment, discharge or satisfaction of any Debt of any other person including any subsidiary, of the character described above, whether arising directly or indirectly. Notwithstanding anything to the contrary contained herein, the term 'Debt' shall exclude any obligation of the Company for borrowed money that it may, from time to time, obtain for its working capital requirements which may be secured by a Lien on the Company's plant, machinery, accounts receivables, inventory, spare parts etc.

- (g) "Directors" means the Directors for the time being of the Company.
- (h) "Facilitation Agreement" means the Facilitation Agreement dated as of 27 June 1996 between the President of the Islamic Republic of Pakistan for and on behalf of the Islamic Republic of Pakistan and the Company.
- (i) "Gas Supply Agreement" means the Gas Supply Agreement dated as of 27 June 1996 between Sui Northern Gas Pipelines Limited and the Company.
- (j) "Guarantee" means the Guarantee given by the President of the Islamic Republic of Pakistan for and on behalf of the Islamic Republic of Pakistan dated as of 27 June 1996 to the Company and NPKAL.

- (k) Deleted
- (l) "Lien" means any mortgage, pledge, lien, interest, conditional or instalment sales agreement, option agreement, claim, charge or encumbrance of any kind.
- (m) "Member" has the meaning assigned thereto in Section 2(1)(21).
- (n) "Month" means a calendar month according to the Gregorian calendar.
- (o) "Note" means the Note issued by the Company to WAPDA pursuant to the Note Agreement.
- (p) "Note Agreement" means the Note Agreement dated 26 June 1996 between WAPDA and the Company.



Deleted

Deleted

"Office" means the registered office for the time being of the Company.

"Oil Supply Agreement" means the Oil Supply Agreement dated as of 27 June 1996 between Pakistan State Oil Company Limited and the Company.

- (u) "Ordinary Resolution" means a resolution passed at a general meeting of the Company when the votes cast (whether on a show of hands or on a poll) in favour of a resolution by Members who, being entitled to vote in person or by proxy, do so vote, exceed the number of votes, if any cast against the resolution by Members so entitled and voting.
- (v) "Ordinance" means The Companies Ordinance, 1984 or any modification or re-enactment thereof for the time being in force.
- (w) "Power Purchase Agreement" means the Power Purchase Agreement dated 27 June 1996 between WAPDA and the Company.
- (x) "Public Offering" means a sale or transfer of shares generally to the public involving a listing of shares on the Karachi Stock Exchange or any other applicable stock

exchange inside or outside Pakistan as opposed to a transaction involving a sale to a limited number of purchasers.

- (y) "Register" means, unless the context otherwise requires, the register of Members to be kept pursuant to Section 147.
- (z) "Relevant Basic Agreements" means the Facilitation Agreement, the Guarantee, the Power Purchase Agreement, the Oil Supply Agreement, the Gas Supply Agreement, the Note Agreement, the Note and the Services Agreement.
- (aa) "Seal" means the common or official seal of the Company.
- (bb) "Section" means a section of the Ordinance.
- (cc) Deleted
- (dd) "Services Agreement" means the Services Agreement dated 27 June 1996 between WAPDA and the Company.
- (ee) "shares" means shares in the ordinary share capital of the Company.
- (ff) Deleted
- (gg) "Special Resolution" means a special resolution of the Company as defined in Section 2(1)(36).
- (hh) "Special Resolution Matters" means, inter alia, those matters specified in Article 41 which are required to be approved by a Special Resolution by the Members at a general meeting of the Company.
- (ii) "US Dollars" and the symbol "US\$" means dollars in the lawful currency of the United States of America.
- (jj) "WAPDA" means the Pakistan Water and Power Development Authority, a statutory corporation established under the Pakistan Water and Power Development Authority Act, 1958.

- (kk) "WAPDA Nominee Directors" means Directors nominated for election by WAPDA.
- (ll) Words importing the masculine gender include all other genders.
- (mm) Words importing the singular number include the plural number and vice versa.
- (nn) Expressions referring to writing shall unless the contrary intention appears, be construed as including references to printing, lithography, photography and other modes of representing or reproducing words in a visible form.
- (oo) Words importing persons shall include individuals, corporations, bodies corporate, partnerships, joint ventures, trusts, unincorporated organisations, governments or governmental authorities or agencies or any other legal entities.
- (pp) The head notes are inserted for convenience and shall not affect the construction of these Articles.
- (qq) Unless the context otherwise requires words or expressions contained in these Articles shall bear the same meaning as in the Ordinance and, in relation to bodies corporate incorporated outside Pakistan, shall apply so that such terms shall be construed in accordance with the meaning of the nearest equivalent term under the laws of the place of incorporation of such body corporate.
- (rr) a reference to any agreement or document is to that agreement or document (and, where applicable, any of its provisions) as amended, novated, restated or replaced from time to time.



II. BUSINESS

3. Public Company

The Directors shall have regard to the restrictions on the commencement of business imposed by Section 146 if, and so far as, those restrictions are binding upon the Company.

III. SHARES

A. General

4. Shares under Directors' Control

Subject to the provisions of the Ordinance and these Articles, the shares of the Company shall be under the control of the Directors, who may allot or otherwise dispose of the same to such persons, on such terms and conditions, and at such times and for such consideration as the Directors think fit.

5. Amount Payable on Application

No shares shall be offered to the public for subscription except upon the term that the amount payable on application shall be the full amount of the nominal amount of the share.

6. Allotment of Shares

No share shall be issued at a discount except in accordance with the provisions of the Ordinance. The Directors shall, as regards any allotment of shares, duly comply with such of the provisions of Sections 68 to 73, as may be applicable to the Company. The minimum subscription upon which the Company may proceed to allot the shares shall be Rs. 10,000/- (Rupees ten thousand).

7. Share Certificates

Every person whose name is entered as a Member in the Register shall, without payment, be entitled to receive within ninety (90) days after allotment or within forty-five (45) days of the application for registration of transfer, a certificate under the Seal specifying the share or shares held by him and the amount paid up thereon including in particular and without limitation such legends as the Company shall be obliged to affix to certain of the certificates by law or as the Company shall have agreed to affix pursuant to any contractual arrangements in this respect. Provided that, in respect of a share or shares held jointly by several persons, the Company shall not be bound to issue more than one certificate, and delivery of a certificate for a share or shares to one of several joint holders shall be sufficient delivery to all.

8. Certificate under Seal

The certificate of title to shares shall be issued under the authority of the Directors or a committee of Directors when authorized thereto by

the Directors in such manner and form as the Directors may from time to time prescribe. The Seal shall be duly affixed to every share certificate issued by the Company. The signature(s) on the certificate of title to shares may be affixed by any mechanical or electronic method.


9. Issuance of new Certificate

If a share certificate is defaced, lost or destroyed, it may be renewed on payment of such fee, if any, not exceeding Rs. 10/- (Rupees ten), and on such terms, if any, as to evidence, indemnity and payment of expenses incurred by the Company in investigating title as the Directors think fit.

10. Joint Holders

The Company shall not be bound to register more than four persons as the joint holders of any share.

11. Trusts Not Recognized



Except as required by law, no person shall be recognized by the Company as holding any shares upon any trust, and the Company shall not be bound by or be compelled in any way to recognize (even when having notice thereof) any equitable, contingent, future or partial interest in any share or any interest in any fractional part of a share or (except only as by these Articles or by law otherwise provided) any other rights in respect of any share except an absolute right to the entirety thereof in the registered holder.

12. Payment of Commission

The Company may at any time pay a commission to any person for subscribing/agreeing to subscribe (whether absolutely or conditionally) for any shares, debentures or debenture-stock in the Company, but so that if the commission in respect of shares shall be paid or payable out of capital, the statutory requirements and conditions shall be observed and complied with, and the amount or rate of commission shall not exceed such percentage on the shares, debentures, debenture-stock in each case subscribed or to be subscribed, as may be determined by the Board subject to any limits required by law. The commission may be paid or satisfied, either wholly or partly, in cash or in shares, debentures or debenture-stock. The Company may also on any issue of shares pay such brokerage as may be lawful; provided that such brokerage shall not exceed such percentage on the shares, debentures or debenture-stock, as may be determined by the Board subject to any limits required by law.

13. Bar on Use of Company Funds

Except to the extent and in the manner allowed by Section 95, no part of the funds of the Company shall be employed in the purchase of, or in loans upon the security of, the Company's shares.

B. Transfer of Shares

14. Transfer

The instrument of transfer of any share in the Company shall be executed by both the transferor and transferee, and the transferor shall be deemed to remain holder of the share until the name of the transferee is entered in the Register in respect thereof.

15. Form of Transfer

Shares in the Company shall be transferred in the following form, or in any usual or common form which the Directors shall approve:

Kot Addu Power Company Limited

I _____ of _____ in consideration of the sum of Rupees _____ paid to me by _____ of _____ (the "Transferee"), do hereby transfer to the Transferee _____ share(s) numbered _____ to _____ (both numbers being inclusive), in Kot Addu Power Company Limited, to hold unto the Transferee, his executors, administrators and assigns, subject to the several conditions on which I held the same at the time of the execution hereof, and I, the Transferee, do hereby agree to take the said share(s) subject to the conditions aforesaid.

As witness our hands this _____ day of _____ 20____

Transferor

Transferee

Signature

Signature

Witnesses:

Full Name, Father's/
Husband's Name

1. _____
Signature

Nationality

Full Address:

Occupation

Full address of transferee

2. _____
Signature

Full Address:



Non-Refusal of Transfer of Shares

The Directors shall not refuse to transfer any fully paid shares unless the transfer deed is defective or invalid. The Directors may decline to recognize any instrument of transfer unless:

- (a) a fee not exceeding two rupees as may be determined by the Directors is paid to the Company in respect thereof; and
- (b) the duly stamped instrument of transfer is accompanied by the certificate of the share to which it relates, and such other evidence as the Directors may reasonably require to show the right of the transferor to make the transfer.

If the Directors refuse to register a transfer of shares, they shall within thirty (30) days after the date on which the instrument of transfer deed was lodged with the Company, notify the defect or invalidity to the transferee, who shall, after removal of such defect or invalidity be entitled to re-lodge the transfer deed with the Company.

17. Closure of Register

On giving seven (7) days previous notice in the manner provided in the Ordinance, the Register may be closed for such period or periods not exceeding forty-five (45) days in any one (1) year as the Directors may

from time to time determine, but not exceeding thirty (30) days at any one time.

C. **Transmission of Shares**

18. Transmission

The executors, administrators, heirs or nominees, as the case may be, of a deceased sole holder of a share shall be the only persons recognized by the Company as having any title to the share. In the case of a share registered in the names of two or more holders, the survivor or survivors, shall be the only persons recognized by the Company as having any title to the share.

Before recognizing any executor, administrator, heir or nominee the Company may request such person(s) to obtain a grant of probate or letters of administration, succession certificate or other legal representation(s), as the case may be, from a competent court, provided nevertheless that where the Company in its absolute discretion thinks fit it shall be lawful for it to dispense with the production of probate or letters of administration or succession certificate or other legal representation(s) upon such terms as to indemnity or otherwise as the Company in its absolute discretion may consider necessary.

19. Election to Register or Transfer

Any person becoming entitled to a share in consequence of the death or insolvency of a Member shall, upon such evidence being produced as may from time to time be required by the Directors, have the right, either to be registered as a Member in respect of the share or, instead of being registered himself, to make such transfer of the share as the deceased or insolvent person could have made; but the Directors shall, in either case have the same right to decline or suspend registration as they would have had in the case of a transfer of the share by the deceased or insolvent person before the death or insolvency.

20. Rights of Person Entitled by Transmission

A person entitled to a share by transmission shall be entitled to receive, and to give a discharge for, any dividends or other money payable in respect of the share, but he shall not be entitled in respect of it to receive notices of, or to attend or vote at, meetings of the Company, or, save as aforesaid, to exercise any of the rights or privileges of a Member, unless he shall become a Member in respect of the share.

D. Alteration of Capital

21. Power to Increase Authorized Capital

The Company may, from time to time, by Special Resolution increase the authorized share capital by such sum, to be divided into shares of such amount, as the resolution shall prescribe.

22. Further Issue of Capital

Where the Directors decide to increase the capital of the Company by issue of further shares, such shares shall be offered to the Members in proportion to the existing shares held by each Member unless a Special Resolution is passed.

23. Provisions Applicable to New Shares

The new shares shall be subject to the same provisions with reference to transfer, transmission and otherwise as the shares in the original share capital.

24. Consolidation and Sub-division

The Company may, by Ordinary Resolution:

- (a) consolidate and divide its share capital into shares of larger amount than its existing shares;
- (b) sub-divide its existing shares or any of them into shares of smaller amount than is fixed by the Company's memorandum of association, subject, nevertheless, to the provisos to Section 92(1)(d);
- (c) cancel any shares which, at the date of the passing of resolution, have not been taken or agreed to be taken by any person.

25. Reduction of Share Capital

The Company may, by Special Resolution, reduce its share capital in any manner and with, and subject to, any incident authorized and consent required by law.

IV. MEETINGS AND PROCEEDINGS

A. General Meetings

26. Statutory Meeting

The statutory general meeting of the Company shall be held within the period required by Section 157.

27. Annual General Meeting

A general meeting to be called the annual general meeting, shall be held, in accordance with the provisions of Section 158, within eighteen (18) Months from the date of incorporation of the Company and thereafter once at least in every year within a period of four (4) Months following the close of its financial year and not more than fifteen (15) Months after the holding of its last preceding annual general meeting as may be determined by the Directors.

28. Other Meetings

All general meetings other than the statutory meeting or an annual general meeting shall be called extraordinary general meetings.

29. Extraordinary Meetings

The Directors may whenever they think fit, call an extraordinary general meeting, and extraordinary general meetings shall also be called on such requisition, or in default, may be called by such requisitionists, as is provided by Section 159. If at any time there are not within Pakistan sufficient Directors capable of acting to form a quorum, any Director of the Company may call an extraordinary general meeting in the same manner as nearly as possible as that in which meetings may be called by the Directors.

B. Notice and Proceedings

30. Notice of Meetings

Notice for a general meeting shall be given in the manner provided by the Ordinance to such persons as are, under the Ordinance or the regulations of the Company, entitled to receive such notices from the Company; but the accidental omission to

give notice to, or the non-receipt of notice by, any Member shall not invalidate the proceedings at any general meeting.

31. Special Business

All business shall be deemed special that is transacted at an extraordinary general meeting, and also all that is transacted at an annual general meeting with the exception of declaring a dividend, the consideration of the accounts, balance sheet and the reports of the Directors and auditors, the election of directors, the appointment of, and the fixing of the remuneration of, the auditors.

32. Quorum

No business shall be transacted at any general meeting unless a quorum of Members is present at that time when the meeting proceeds to business. The quorum for general meetings shall be not less than ten Members present in person or by proxy who between them hold shares representing at least twenty five percent (25%) of the total issued shares; provided that that number must include at least one of WAPDA's representatives or proxies for so long as WAPDA continues to hold not less than twenty five per cent (25%) of the total issued shares.



Effect of Quorum Not Being Present

If within half an hour from the time appointed for the meeting a quorum is not present, the meeting, if called upon the requisition of Members, shall be dissolved; in any other case, it shall stand adjourned to the same day in the next week at the same time and place, and, if at the adjourned meeting a quorum is not present within half an hour from the time appointed for the meeting, the Members present, being not less than two, shall be a quorum.

34. Chairman of Meeting

The chairman of the Board of Directors, if any, shall preside as chairman at every general meeting of the Company, but if there is no such chairman, or if at any meeting he is not present within fifteen (15) minutes after the time appointed for the meeting, or is unwilling to act as chairman, any one of the Directors presents may be elected to be chairman, and if none of the Directors is present, or willing to act as chairman, the Members present shall choose one of their number to be chairman.

35. Adjournment

The chairman may, with the consent of any meeting at which a quorum is present (and shall if so directed by the meeting), adjourn the meeting from time to time but no business shall be transacted at any adjourned meeting other than the business left unfinished at the meeting from which the adjournment took place. When a meeting is adjourned for ten (10) days or more, notice of the adjourned meeting shall be given as in the case of an original meeting. Save as aforesaid, it shall not be necessary to give any notice of an adjournment or of the business to be transacted at an adjourned meeting.

36. Voting

36.1 At any general meeting a resolution put to the vote of the meeting shall be decided on a show of hands unless a poll is (before or on the declaration of the result of the show of hands) demanded. Unless a poll is so demanded, a declaration by the chairman that a resolution has, on a show of hands, been carried, or carried unanimously, or by a particular majority, or lost, and an entry to that effect in the book of the proceedings of the Company shall be conclusive evidence of the fact, without proof of the number or proportion of the votes recorded in favor of, or against that resolution.

36.2 For general meetings, the Company shall comply with the e-voting requirements as notified in the Companies (E-Voting) Regulations, 2016 (as amended) or as otherwise prescribed by the Securities and Exchange Commission of Pakistan.

37. Poll: Demand for: Manner and Time of Taking:

37.1 A poll may be demanded only in accordance with the provisions of Section 167.

37.2 If a poll is duly demanded, it shall be taken in accordance with the manner laid down in Section 168 and the result of the poll shall be deemed to be the resolution of the meeting at which the poll was demanded.

37.3 A poll demanded on the election of chairman or on a question of adjournment shall be taken at once.

38. Casting Vote

In the case of an equality of votes, whether on a show of hands or on a poll, the Chairman of the meeting at which the show of hands takes place, or at which the poll is demanded, shall not have or exercise a second or casting vote.

38.1 Right Of Directors To Attend General Meetings

Every Director of the Company shall have the right to attend any general meeting of the Company and also to take part in the discussion thereat.

39. Resolutions at General Meetings

Special Resolution Matters will require a Special Resolution at a general meeting.

40. Resolution Passed at Adjourned Meeting.

Where a resolution is passed at an adjourned meeting of:

- (a) the Company;
- (b) the holders of any class of shares in the Company;
- (c) the directors of the Company; or
- (d) the creditors of the Company;

the resolution shall, for all purposes, be treated as having been passed on the date on which it was in fact passed, and shall not be deemed to have been passed on any earlier date.

41. Special Resolution Matters

The following matters require a Special Resolution:

- (a) any change in the authorised ordinary share capital of the Company, or the issuance of any additional ordinary share capital or of any option or right to subscribe to additional ordinary share capital of the Company; provided, however, that the Company may issue (i) additional shares of ordinary share capital in a pre-emptive rights offering to all Members, (ii) debenture stock and (iii) in the event that the applicable laws of Pakistan authorise the issuance of non-voting ordinary share capital, shares of non-voting ordinary share capital to WAPDA in exchange for its shares of voting ordinary share capital.
- (b) sale or issuance of any interest in the Company giving any right to participate in the profits of the Company or in respect of profits relating to any asset of the Company or

conferred on any person (including any of the Members) including but not limited to net profit interest agreements or any arrangements for sharing income or profits except to the extent that the same are entered into as a part of an incentive compensation arrangement in connection with the provision of goods or services to the Company upon terms that (taking into account such arrangement) are competitive in the relative market;

(c) incurring any new Debt, where the principal exceeds five hundred thousand US Dollars (US\$500,000) (or its equivalent in any currency) other than for the purpose of refinancing any existing Debt provided that (i) the refinancing Debt is at a lower cost of funds to the Company than such existing Debt and (ii) the principal amount of such refinancing Debt does not exceed the outstanding principal balance of such existing Debt at the time the refinancing is issued;

(d) the acquisition, disposal, sale, transfer, lease, licence or other disposal of any asset (including shares) or interest in an asset (other than in the ordinary course of business), in any single transaction, or series of transactions, where the net proceeds of such transaction or transactions exceed, in the aggregate, five hundred thousand US Dollars (US\$500,000) (or its equivalent in any currency).

(e) making any loan other than credit given in the normal course of the Company's business, providing any guarantee or indemnity (other than in the normal course of business) or granting any security interest over any of the assets of the Company to support the obligations of a third party;

(f) repurchasing any shares other than for the then fair market value thereof other than in connection with the issuance of non-voting Ordinary Share Capital to WAPDA in exchange for its shares of voting Ordinary Share Capital and provided further that such repurchase is in accordance with the procedures for repurchase established by the applicable laws of Pakistan;

(g) the initiation, conduct, defence, compromise or settlement of any claim or series of claims by or against the Company involving an amount, which either individually or in the aggregate, is in excess of five million Dollars (US \$5,000,000) (or its equivalent in any currency);

(h) any amendment of any of the Relevant Basic Agreements, the exercise or waiver of any material right of the

Company under any of the Relevant Basic Agreements, or the initiation, conduct, defence, compromise or settlement of any claim by or against the Company under any of the Relevant Basic Agreements;

(i) the removal of any Director, or any other change in the number or composition of the Board of Directors;

(j) any Public Offering ;

(k) fixing the dividend policy or any change to the dividend policy of the Company;

42. The replacement of the Company's auditors shall be a Special Resolution Matter, unless the firm to be appointed to replace the existing firm is either one of the following leading international accountants, namely PriceWaterhouseCoopers, Ernst & Young, Deloitte and KPMG (the "Big 4 Firms"), or the associate firm in Pakistan of one of the Big 4 Firms in which case a Special Resolution will not be required.

C. Votes of Members

43. Right to Vote

Subject to any rights or restrictions for the time being attached to any class or classes of shares, on a show of hands every Member present in person shall have one vote except for election of directors in which case the provisions of Section 178 shall apply. On a poll every Member shall have voting rights as laid down in Section 160.

44. Voting By Joint Holders

In case of joint-holders the vote of the senior who tenders a vote, whether in person or by proxy shall be accepted to the exclusion of the votes of the other joint-holders and for this purpose seniority shall be determined by the order in which the names stand in the Register.

45. Member Of Unsound Mind

A Member of unsound mind or in respect of whom an order has been made by any court having jurisdiction in lunacy, may vote, whether on show of hands or on a poll, by his committee or other legal guardian, and any such committee or guardian may, on a poll, vote by proxy.

46. Voting: Corporation Representatives

On a poll, votes may be given either personally or by proxy. Provided that no body corporate shall vote by proxy unless a resolution of its directors in accordance with the provisions of Section 162 is in force.

47. Proxy to be in Writing

47.1 The instrument appointing a proxy shall be in writing under the hand of the appointer or of his attorney duly authorized in writing or if the appointer is a body corporate be under its seal or be signed by an officer or an attorney duly authorised by it. A proxy must be a Member of the Company.

47.2 At a general meeting, in case of e-voting, a proxy may or may not be a Member of the Company.

48. Instrument Appointing Proxy to be Deposited

The instrument appointing a proxy and the power-of-attorney or other authority (if any) under which it is signed, or a notarially certified copy of that power or authority, shall be deposited at the Office not later than forty-eight hours before the time for holding the meeting at which the person named in the instrument proposes to vote and in default the instrument of proxy shall not be treated as valid.

49. Form of Proxy

An instrument appointing a proxy may be in the following form, or a form as near thereto as may be:

KOT ADDU POWER COMPANY LIMITED

I _____ of _____
_____ in the district of _____
being a Member of Kot Addu Power Company Limited,
hereby appoint _____ of _____ as my proxy
to vote for me and on my behalf at the
(annual/extraordinary as the case may be) general
meeting of the Company to be held on the [] day of []
and at any adjournment thereof.

49 A E-Voting

Members opting for e-voting shall communicate their intention to opt for e-voting and demand of poll for resolutions through an instrument of e-voting to the Company at least ten (10) days before holding of the general meeting, through regular mail or electronic mail at the registered address/email of the Company provided in the notice of the general meeting. The instrument of e-voting and demand of poll for resolution shall be in the following form or a form as near thereto as may be:

KOT ADDU POWER COMPANY LIMITED

Option 1

Appointing other person as Proxy

I/We, _____ of _____ being member of Kot Addu Power Company Limited, holder of _____ share(s) as per Register Folio No. _____ hereby Appoint _____, Folio No. (if member) _____ of _____ or failing him/her _____, Folio No. (if member) _____ of _____ as my / our proxy in my / our absence to attend and vote for me / us, and on my / our behalf at the Annual General Meeting / Extraordinary General Meeting of the Company to be held on _____ and at any adjournment thereof. Signed under my / our hand this _____ date of _____.



Signature should agree
with the specimen signature
registered with the Company

Signed in the presence of:

Signature of witness
CNIC

Signature of witness
CNIC

Option 2

E-Voting as per the Companies (E-voting) Regulations, 2016

I/We, _____ of _____ being a member of
Kot Addu Power Company Limited, holder of _____
share(s) as per Register Folio No. _____ hereby opt for e-voting through
Intermediary and hereby consent the appointment of execution officer (ABC)
as proxy and will exercise e-voting as per The Companies (e-voting)
Regulations, 2016 and hereby demand for poll for resolutions.

My secured email address is _____, please send me login
details, password and electronic signature through email.

Signature should agree
with the specimen signature
registered with the Company

Signed in the presence of:

Signature of witness
CNIC

Signature of witness
CNIC



50. Revocation of Authority

A vote given in accordance with the terms of an instrument of proxy shall be valid notwithstanding the previous death or insanity of the principal or revocation of the proxy or of the authority under which the proxy was executed, or the transfer of the share in respect of which the proxy is given, provided that no intimation in writing of such death, insanity, revocation or transfer as aforesaid shall have been received by the Company at the Office before the commencement of the meeting or adjourned meeting at which the proxy is used.

V. MANAGEMENT AND ADMINISTRATION

A. Board of Directors

51. Directors

The first Directors of the Company shall be:

- (1) Mr. Khalid Jawed
- (2) Mr. Bashir Ahmed Abbasi
- (3) Mr. Javed Aslam Callea
- (4) Mr. Khalid Mohtadullah
- (5) Mr. Akbar Khan
- (6) Mr. Justice (Retd) Ch. Khalid Mehmood
- (7) Mr. Arshad Zaman

and two other persons who shall be nominated by a majority of the Subscribers to the Memorandum within a period ending six months from the date of incorporation and in any case not later than thirty five (35) days prior to the first annual general meeting of the Company (hereinafter collectively referred to as the "First Directors"). The First Directors shall hold office until the first annual general meeting of the Company.

52. Number of Elected Directors



52.1 The number of elected Directors shall be seven (or such other number as may be specified through a Special Resolution) and shall be not less than the minimum number required from time to time by applicable laws of Pakistan for a company of the type which the Company is.

52.2 Deleted

52.3 Directors nominated for election by WAPDA are herein referred to as "WAPDA Nominee Directors".

52.4 The Directors shall be elected in accordance with the provisions of Section 178 (5).

52.5 In addition to the Directors elected or deemed to have been elected under Article 52, the Company may have up to one (1) Director nominated by the Company's creditors or other special interests by virtue of contractual arrangements.

53. Chairman of the Board

The Directors may elect one of their number as the Chairman of the Board and vest in him such powers and functions as they may deem fit in relation to the management and administration of the affairs of the Company subject to their general supervision and control.

54. Chief Executive

The Chief Executive shall be appointed by the Directors in accordance with Section 199 and shall be entitled to all the rights and privileges and subject to all the liabilities of that office. The Directors may vest in him such powers and functions as they deem fit in relation to the management and administration of the affairs of the Company subject to their general supervision and control.

55. Remuneration

Subject to any approval or limits required by law, the terms and conditions and remuneration of:

- (a) Director for performing extra services, including the holding of the office of Chairman,
- (b) the Chief Executive, and
- (c) any Director for attending the meetings of the Directors or a Committee of Directors

shall be determined by the Board of Directors.

56. Alternate Director

56.1 A Director may appoint any person qualified to be appointed as a Director in accordance with these Articles, except that an alternate Director shall not require any share qualification, or another Director to be his alternate Director.

56.2 Any appointment or removal under this Article shall be made by notice in writing signed by the Director making the same and need not be in any particular format as long as its intent and the name of the person appointed or removed are clearly stated. Such notice may be sent to the Company or tabled at a Board meeting by the appointing Director or his proposed alternate. Upon receipt by the Company or upon being tabled at a Board

meeting as aforesaid, the appointment of the alternate Director shall be deemed to have been approved by the Board.

56.3 Such an alternate Director shall be entitled to notice of meetings of the Directors and to attend and vote thereat accordingly and generally to exercise all the rights of such absent Director subject to any limitations in the instrument appointing him. For the purposes of the proceedings at such meetings, the provisions of these Articles shall apply as if any alternate Director (instead of his appointer) were a Director.

56.4 An alternate Director shall ipso facto vacate office as and when his appointer (a) vacates office as a Director; (b) removes the appointee from office; or (c) returns to Pakistan. Provided upon each occasion upon which the appointer thereafter leaves Pakistan again, and unless the appointer shall have informed the Company to the contrary, he shall be deemed to have reappointed the appointee as his alternate Director and no further approval of the Board shall be required unless the appointer desires to approve another person not previously approved by the Board as his alternate and takes the necessary steps to do so pursuant to this Article 56.

56.5 If an alternate Director shall be himself a Director, his voting rights shall be cumulative but he shall not be counted more than once for the purposes of quorum.



B Powers and Duties of Directors

57. General Management Powers

The business of the Company shall be managed by the Directors, who may pay all expenses incurred in promoting and registering the Company, and may exercise all such powers of the Company as are not by the Ordinance or by these regulations, required to be exercised by the Company in general meeting, subject nevertheless to the provisions of the Ordinance or to any of these regulations, and such regulations being not inconsistent with the aforesaid provisions, as may be prescribed by the Company in general meeting but no regulation made by the Company in general meeting shall invalidate any prior act of the Directors which would have been valid if that regulation had not been made.

58. Borrowing Powers

Subject to the provisions of Article 41, the Board may exercise all the powers of the Company to borrow money and to mortgage or charge its undertaking, property and assets (both present and future), and to issue debentures, debenture stock, and other securities, whether outright or as collateral security for any debt, liability or obligation of the Company or of any third party.

59. Duties of Directors

The Directors shall duly comply with the provisions of the Ordinance and in particular with the provisions in regard to the registration of the particulars of mortgages and charges affecting the property of the Company or created by it, to the keeping of a register of the Directors, and to the sending to the registrar of an annual list of Members and a summary of particulars relating thereto, and notice of any consolidation or increase of share capital, or sub-division of shares, and copies of Special Resolutions and a copy of the register of Directors and notifications of any changes therein.

60. Minute Books

The Directors shall cause minutes to be made in books provided for the purpose of:

- (a) all appointments of officers made by the Directors;
- (b) the names of the Directors present at each meeting of the Directors and of any committee of the Directors;
- (c) all resolutions and proceedings at all meetings of the Company and of the Directors and of committees of Directors; and every Director present at any meeting of Directors or committee of Directors shall sign his name in a book to be kept for that purpose.

C. Disqualification of Directors

61. Disqualification of Directors

61.1 No person shall be appointed or become a Director:

- (a) if he is not a Member (except in the case of the Chief Executive); or

(b) if he suffers from any of the other disabilities or disqualifications mentioned in Section 187;

(c) if, in the case of a WAPDA Nominee Director, he is not an officer of WAPDA or any Affiliate of WAPDA.

61.2 A Director shall cease to hold office as a Director:

(a) if he becomes disqualified or disabled from being a Director on any of the grounds mentioned in Section 187; or

(b) if he is removed by a resolution of the Members as hereinafter provided; or

(c) if by notice in writing given to the Company he resigns his office; or

(d) if he fails to acquire his qualification shares within two (2) Months of his appointment; or

(e) if, in the case of a WAPDA Nominee Director, he ceases to be an officer of WAPDA or any Affiliate of WAPDA: or

(f) if he accepts a loan or guarantee from the Company in contravention of Section 195 ;

Provided, however, that no Director shall vacate his office by reason only of his being a Member of any company which has entered into contracts with, or done any work for, the Company but such Director shall not vote in respect of any such contract or work, and if he does so vote, his vote shall not be counted.

D. Proceedings of Directors

62. Meetings of Directors

62.1 The Directors may meet together for the despatch of business, adjourn and otherwise regulate their meetings, as they think fit. A Director may and the secretary on the requisition of a Director shall, at any time, summon a meeting of Directors. Seven (7) days notice at the least (exclusive of the day on which the notice is served or deemed to be served, but inclusive of the day for which notice is given) shall be given for a meeting of Directors provided that, if all the Directors entitled to attend and vote at any such meeting so agree, in writing, a meeting may be held of which less than seven (7) days notice has been

given. It shall be necessary to give notice of a meeting of Directors to any Director for the time being absent from Pakistan.

- 62.2 The Directors may, if circumstances so require, hold Board Meetings by video-conference or by telephone conference call provided that each Director is able to hear and identify all other Directors speaking on the call. A video-conference or telephone conference call may be recorded and the recording preserved for the purpose of preparing minutes and as a record of the meeting.

63. Quorum at Board Meetings

- 63.1 The quorum for meetings of the Board of Directors shall be four Directors or one third of the Board (whichever is higher) present in person; provided that that number must include at least one Director nominated by WAPDA for as long as WAPDA retains a shareholding of at least 26%.

- 63.2 If at any meeting of the Board of Directors of which proper notice has been given, a quorum is not present thirty (30) minutes after the scheduled start time for the meeting, the meeting shall be adjourned to the same time and place on the date which is seven (7) calendar days after the date of the original meeting.

64. Resolutions at a Board Meeting

All resolutions of the Board of Directors shall be effective if passed by a majority of the Directors present at a properly convened meeting of the Board of Directors at which a quorum as required by Article 63 is present.

65. Chairman of Directors Meetings

The Chairman of the Board shall preside at all meetings of the Board but, if at any meeting the chairman is not present within ten (10) minutes after the time appointed for holding the same or is unwilling to act as chairman, the Directors present may choose one of their number to be chairman of the meeting.

66. Committees

- 66.1 The Directors may delegate any of their powers not required to be exercised in their meeting to committees consisting of such member or members of their body as they think fit. Any committee so formed shall, in the exercise of the powers so

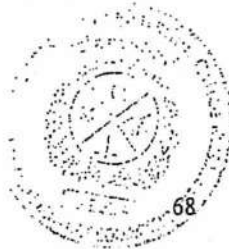
delegated, conform to any restrictions that may be imposed on it by the Directors.

66.2 A committee may elect a chairman of its meetings, but, if no such chairman is elected, or if at any meeting the chairman is not present within ten (10) minutes after the time appointed for holding the same or is unwilling to act as chairman, the members present may choose one of their number to be chairman of the meeting.

66.3 A committee may meet and adjourn as it thinks proper. Questions arising at any meeting shall be determined by a majority of votes of the members present. In case of an equality of votes, the chairman shall have and exercise a second or casting vote.

67. Validity of Directors' Acts

All acts done by any meeting of the Directors or of a committee of Directors, or by any person acting as a Director, shall, notwithstanding that it be afterwards discovered that there was some defect in the appointment of such Directors or persons acting as aforesaid, or that they or any of them were disqualified; be as valid as if every such person had been duly appointed and was qualified to be a Director.



68. Resolution in Writing

Except for the matters specified in Section 196(2), a Resolution in writing signed by all the Directors for the time being in office shall be as valid and effectual as if it had been passed at a meeting of the Board duly called and constituted. For this purpose, it shall be permissible to circulate the text of the proposed resolution duly signed by the Chief Executive and obtain the signatures of all the other Directors thereon separately by fax (the signed original whereof shall be sent in due course by mail or courier to the Company for its record) and such resolution shall be effective as soon as the text of the resolution signed by each of the other Directors shall have been faxed to and received by the Company.

E. Election and Removal of Directors

69. First Election of Directors

At the first annual general meeting of the Company, all the Directors shall stand retired from office, and Directors shall be

elected in their place in accordance with Section 178 for a term of three (3) years.

70. Eligibility for Re-election

A retiring Director shall be eligible for re-election.

71. Election in Accordance with Ordinance

The Directors shall comply with the provisions of Sections 174 to 178 and Sections 180 and 184 relating to the election of Directors and matters ancillary thereto.

Notwithstanding that the number of persons offering themselves for election as Directors is not more than the number of Directors fixed under Article 52, the number of votes cast in favour of each candidate and the name of the Member casting such votes shall be recorded in the minutes of the meeting.

72. Filling casual Vacancy

Any casual vacancy occurring on the Board of Directors may be filled up by the Directors; Provided that if the casual vacancy occurs because a WAPDA Nominee Director ceases to be a Director, WAPDA may nominate a person qualified for appointment as Director to fill the vacancy and the Directors shall appoint such person to fill the vacancy. The person so chosen shall be subject to retirement at the same date as if he had become a Director on the day on which the Director in whose place he is chosen was last elected as Director.

73. Removal of Director

The Company may remove a Director in accordance with Article 41(i) to the extent not inconsistent with the provisions of the Ordinance.

VI. THE SEAL

74. Common Seal

The Directors shall provide a common seal of the Company which shall not be affixed to any instrument except by the authority of a resolution of the Board or by a committee of Directors authorized in that behalf by the Directors, and two Directors or one Director and the secretary of the Company shall sign every instrument to which the common seal is affixed.

75. Official Seal

The Directors may provide for the use in any territory, district or place not situated in Pakistan, of an official seal which shall be a facsimile of the common seal of the Company, with the addition on its face of the name of every territory, district or place where it is to be used. The provisions of Section 213 shall apply to the use of the official seal.

VII. DIVIDENDS AND RESERVE

76. Declaration of Dividends

The Company in general meeting may declare dividends but no dividend shall exceed the amount recommended by the Directors.

77. Interim Dividends

The Directors may from time to time pay to the Members such interim dividends as appear to the Director to be justified by the profits of the Company.

78. Dividends Payable Out of Profits

No dividends shall be paid otherwise than out of profits of the year or any other undistributed profits. No unpaid dividend shall bear interest against the Company.

79. Dividends Payable on Amount Paid on Shares

All dividends shall be declared and paid according to the amounts paid on the shares.

80. Reserve Fund

The Directors may, before recommending any dividend, set aside out of the profits of the Company such sums as they think proper as a reserve or reserves which shall, at the discretion of the Directors, be applicable for meeting contingencies, or for equalizing dividends, or for any other purpose to which the profits of the Company may be properly applied, and pending such application may, at the like discretion, either be employed in the business of the Company or be invested in such investments (other than shares of the Company) as the Directors may, subject to the provisions of the Ordinance, from time to time think fit.

81. Profit Carried Forward

The Directors may carry forward any profits which they may think prudent not to distribute, without setting them aside as a reserve.

82. Payment of Dividends in Specie

With the sanction of a general meeting any dividend may be paid wholly or in part by the distribution of specific assets and in particular of paid-up shares or debentures of any other company or in any one or more of such ways. Where any difficulty arises in regard to such distribution, the Directors may settle the same as they think expedient, and in particular may fix the value for distribution of such specific assets or any part thereof and may determine that cash payments shall be made to any Members upon the footing of the value so fixed, in order to adjust the rights of all Members, and may vest any such specific assets in trustees upon trust for the Members entitled to the dividend as may seem expedient to the Directors.

83. Dividends to Joint Holders

If several persons are registered as joint-holders of any share, any one of them may give effectual receipt for any dividend payable on the share.

84. Unclaimed Dividends

All dividends unclaimed for one (1) year after being declared may be invested or otherwise made use of by the Board for the benefit of the Company until claimed.

85. Period for Payment of Dividend

The dividend shall be paid within the period laid down in Section 251.

VIII. ACCOUNTS

86. Books of Account

The Directors shall cause to be kept proper books of account as required under Section 230.

87. Place where Accounts Kept

The books of account shall be kept at the Office or at such other place as the Directors shall think fit and shall be open to inspection by the Directors during business hours.

88. Inspection by Members

The Directors shall from time to time determine whether and to what extent and at what time and places and under what conditions or regulations the accounts and books or papers of the Company or any of them shall be open to the inspection of Members not being Directors, and no Member (not being a Director) shall have any right of inspecting of any account and book or papers of the Company except as conferred by law or authorized by the Directors or by the Company in general meeting.

89. Annual Accounts and Balance Sheet

The Directors shall as required by Sections 233 and 236 cause to be prepared and to be laid before the Company in general meeting such profit and loss accounts and balance sheets duly audited and reports as are referred to in those Sections.

90. Compliance with Ordinance

The Directors shall in all respects comply with the provisions of Sections 230 to 247 as may be applicable.

91. Capitalization of Profits

The Company in general meeting may upon the recommendation of the Directors, resolve that it is desirable to capitalize any part of the amount for the time being standing to the credit of any of the Company's reserve accounts or to the credit of the profit and loss account or otherwise available for distribution, and accordingly that such sum be set free for distribution among the Members who would have been entitled thereto if distributed by way of dividend and in the same proportions, on condition that the same be not paid in cash but be applied in or towards paying up in full un-issued shares or debentures of the Company to be allotted and distributed, credited as fully paid up to and amongst such Members in the proportion aforesaid, and the Directors shall give effect to such resolution.

92. Audit

Auditors shall be appointed and their duties regulated in accordance with Sections 252 to 255.

IX. NOTICES

93. Notice to Members, etc.

Notice shall be given by the Company to Members and auditors of the Company and other persons entitled to receive notice in accordance with law.

X. SECRECY

94. Secrecy

Every Director, manager, adviser, auditor, trustee, Member of a committee, officer, servant, agent, accountant or other person employed in the business of the Company shall, if so required by the Directors before entering upon his duties, sign a declaration pledging himself to observe a strict secrecy respecting all transactions of the Company with its customers and the state of accounts with individuals and in matters relating thereto, and shall by such declaration pledge himself not to reveal any of the matters which may come to his knowledge in the discharge of his duties except when required to do so by the Directors or by any general meeting or by a court of law and except so far as may be necessary in order to comply with any of the provisions in these presents.

95. Members' Access to Company Premises

No Member or other person (not being a Director) shall be entitled to enter upon the property of the Company or examine the Company's premises or properties without the permission of the Board Director, subject to Article 88, to require discovery of or any information respecting any detail of the Company's trading or any matter which is or may be in the nature of a trade secret, mystery of trade, or secret process or of any matter whatsoever which may relate to the conduct of the business of the Company and which in the opinion of the Board will be inexpedient, in the interest of the Members of the Company, to communicate.

XI. RECONSTRUCTION

96. Reconstruction

On any sale of the undertakings of the Company the Directors or the liquidators on a winding up may, if authorized by a Special Resolution, accept fully paid share, debentures or securities of any other company, either then existing or to be formed for the purchase in whole or in part

of the property of the Company, and the Directors (if the profits of the Company permit), or the liquidators (in a winding up), may distribute such shares or securities, or any other properties of the Company amongst the Members without realization, or vest the same in trustees for them, and any Special Resolution may provide for the distribution or appropriation of the cash, shares or other securities, benefits or property, otherwise than in accordance with the strict legal rights of the Members or contributories of the Company, and for the valuation of any such securities or property at such price and in such manner as the meeting may approve, and all holders of shares shall be bound to accept and shall be bound by any valuation or distribution so authorized, and waive all rights in relation thereto save only such statutory rights (if any) as are, in case the Company is proposed to be or is in the course of being wound up, incapable of being varied or excluded by these presents.

XII. WINDING UP

97. Division and Distribution of Assets Upon Dissolution



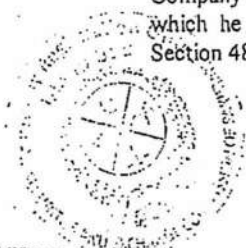
If the Company is wound up, the liquidator may, with the sanction of a Special Resolution of the Company and any other sanction required by law, divide amongst the Members in specie or kind the whole or any part of the assets of the Company (whether they shall consist of property of same kind or not) and may, for such purpose, set such value as he deems fair upon any property to be divided as aforesaid and may determine how such division shall be carried out as between the Members or different classes of Members. The liquidator may, with the like sanction, vest the whole or any part of such assets in trustees upon such trust for the benefit of the contributories, as the liquidator with the like sanction, shall think fit, but so that no Member shall be compelled to accept any shares or other securities whereon there is any liability.

XIII. INDEMNITY

98. Indemnification

Subject to the provisions of Section 194, every Director, Chief Executive and other officer or agent for the time being of the Company shall be indemnified by the Company against (and the Board shall out of funds of the Company pay) all costs, losses and expenses which any officer or servant may incur or become liable to pay by reason of any contract entered into or act or thing done by him as such officer or agent or in any way in the proper discharge of his duties including travel expenses and in particular and so as not to limit the generality of the foregoing provisions against all liabilities incurred by him in defending

any proceedings, whether civil or criminal, except those brought by the Company against him, in which judgement is given in his favour or in which he is acquitted, or in connection with any application under Section 488 in which relief is granted to him by the court.



ORIGINAL TO BE FILED COPY

[Signature]
Deputy Registrar
Company Registration Office Islamabad

ANNEXURE C

CERTIFICATE OF INCORPORATION

GOVERNMENT OF PAKISTAN



CERTIFICATE FOR COMMENCEMENT OF BUSINESS

[Under section 146 (2) of the Companies Ordinance, 1984 (XLVII of 1984)]

COMPANY REGISTRATION NO. I-01977

I hereby certify that the "KOT ADDU POWER COMPANY LIMITED"

which was incorporated under the
Companies Ordinance, 1984 (XLVII of 1984), on the 25th
day of April 1996 and which has filed a duly verified
declaration in the prescribed form that the conditions of clauses (a) to (e) of sub-section
(1) of section 146 of the said Ordinance have been complied with, is entitled to
commence business.

Given under my hand at Islamabad
this 24th day of June
one thousand nine hundred and ninety-six

Fee Rs. 100/-

C.R.O.-4



(BISMILLAH)
DEPUTY REGISTRAR
OF
COMPANIES
ISLAMABAD

CERTIFIED TRUE COPY

No. DR-2/2851 dt 24/6

GOVERNMENT OF PAKISTAN



CERTIFICATE OF INCORPORATION

(Under section 32 of the Companies Ordinance, 1984 (XLVII of 1984))

Company Registration No. I-01977

I hereby certify, that "KOT ADDU POWER COMPANY LIMITED"

is this day incorporated under the Companies Ordinance, 1984
(XLVII of 1984) and that the company is limited by shares

Given under my hand at Islamabad

this 25th day of April

one thousand nine hundred and ninety six

Fee Rs. 2,500,000/- (Rupees Twenty five lac only)

CRO-1.



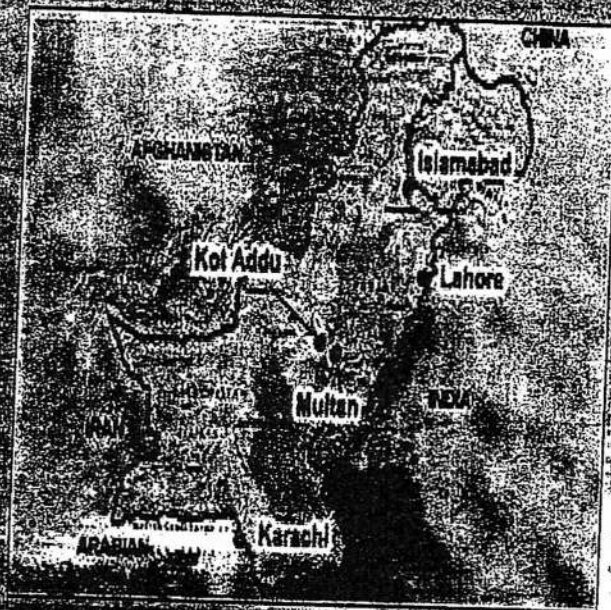
Deputy Registrar
Company Registration Office
Islamabad

(BISMILLAH)
DEPUTY Registrar
of Companies
ISLAMABAD

ANNEXURE D

SITE MAP

KAPCO Plant Site Location

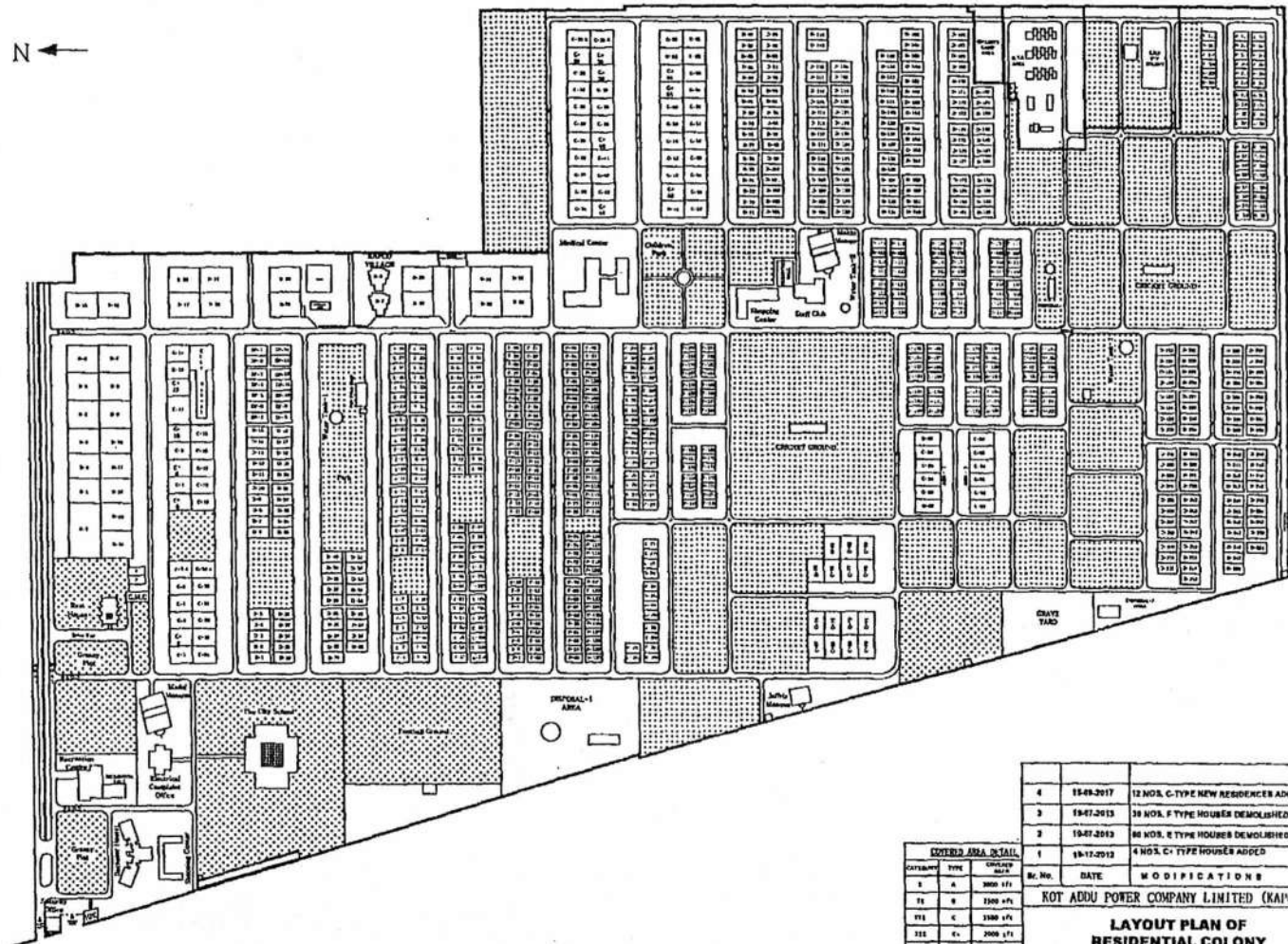


Prepared by the Ministry of Water & Power
Government of Punjab, Pakistan

ANNEXURE E

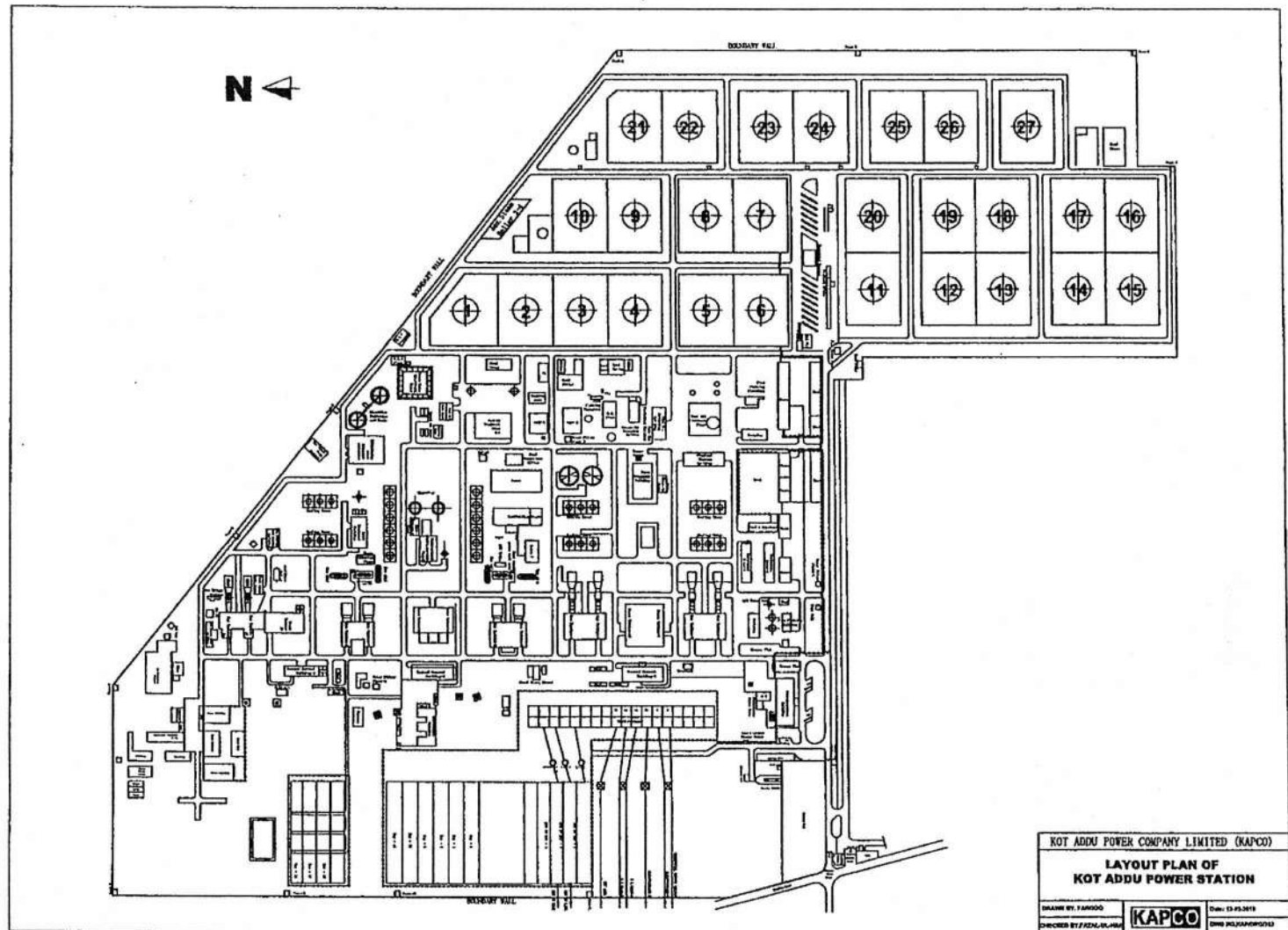
PLANT AND COLONY LAY-OUT

N



COVERED AREA DETAIL		
CITY/STATE	TYPE	COVERED AREA
1	A	3000 sq ft
2	B	1500 sq ft
3	C	1500 sq ft
4	D	2000 sq ft
5	E	1500 sq ft
6	F	1500 sq ft

4	15-08-2017	12 NOS. C-TYPE NEW RESIDENCES ADDED.
3	19-07-2013	38 NOS. F-TYPE HOUSES DEMOLISHED
2	19-07-2013	86 NOS. E-TYPE HOUSES DEMOLISHED
1	19-12-2013	4 NOS. C-TYPE HOUSES ADDED
MODIFICATION B		
No.	DATE	MODIFICATION B
KOT ADDU POWER COMPANY LIMITED (KAPCO)		
LAYOUT PLAN OF RESIDENTIAL COLONY		
DRAWN: FAROOQ		
CHECKED: FAZAL SB.		
KAPCO		
DATE: 04-04-2010		
NO. KAPR00234		



KOT ADDU POWER COMPANY LIMITED (KAPCO)	
LAYOUT PLAN OF KOT ADDU POWER STATION	
DESIGNED BY: T. ARSAD	DATE: 13-05-2019
CHECKED BY: F. H. K. A. S. A. S. A.	DWG NO: KAPCO/PS/013

ANNEXURE F

SINGLE LINE KEY DIAGRAM



National Transmission & Despatch Company Ltd

Phone # : 051 - 4939217
PLC # : 4903
Fax # : 051 - 9250532/4939227

Office of the
General Manager (S.O)
National Power Control Centre
NTDC, H - 8/1, Islamabad.

No. 4119-25/GM(SO)/Addl.C.E (NRCC)/(Drawing).

Dated: 26/03/2021.

General Manager Engineering,
KAPCO, Kot Addu.

Subject Single Line Key Diagram Of 220/132 kV Kot Addu Switchyard

Reference: : Office letter No. KCW/2510/11 dated 24-03-2021

Enclosed please find herewith 'final single line diagram' of subject Power Plant as per information provided/verified vide above referred letter. Kindly ensure that the designated operational code numbers have been properly marked on the respective equipment in Control room, Relay room and Switch yard. Any discrepancy observed in final drawing, be conveyed to the undersigned at the earliest.

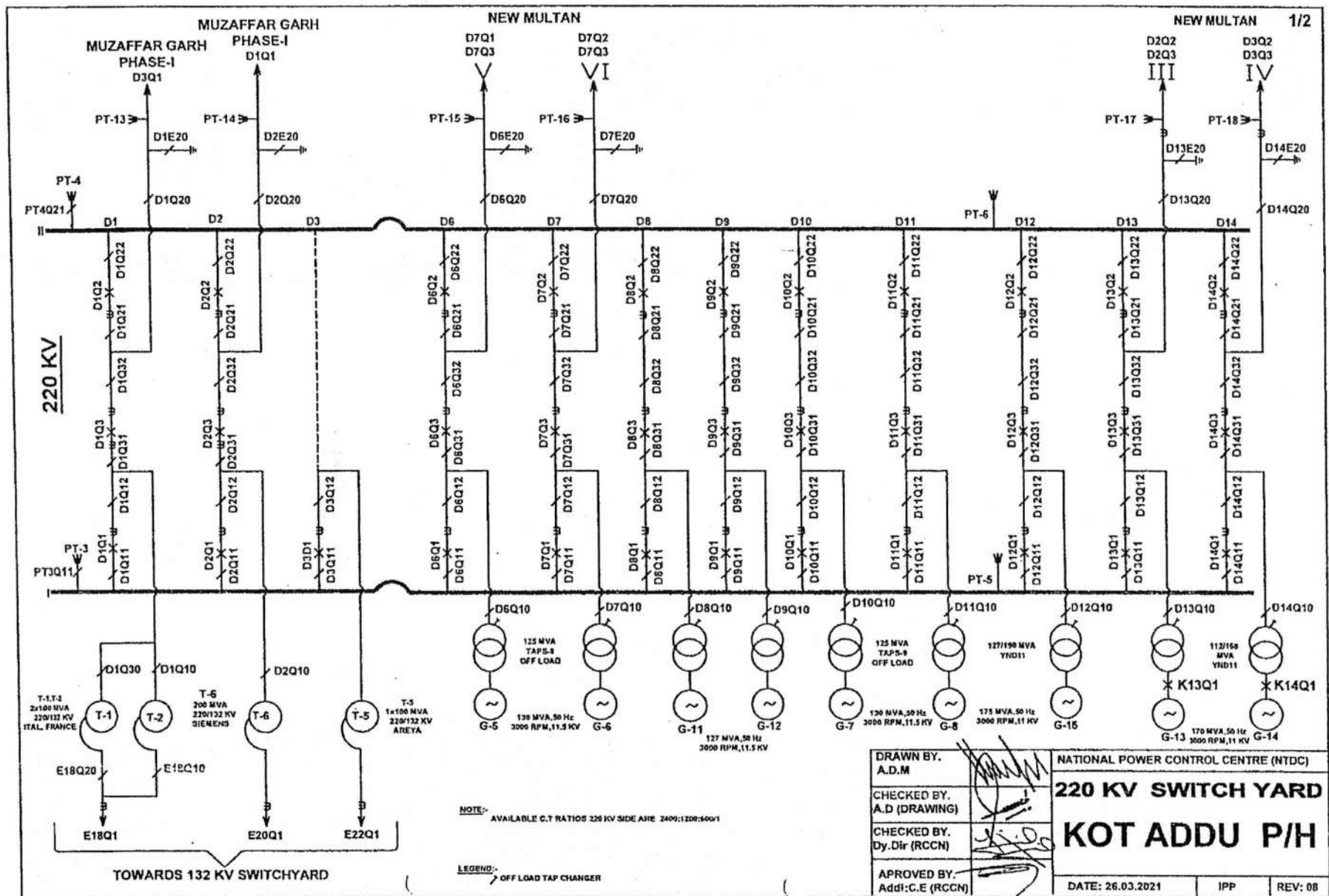
PURPOSE: *Proposed replacement of 220/132kV, Auto-Transformers T-3&4(2*100MVA) with 220/132kV, Auto-Transformer T-6(200MVA).
(As per up gradation work due to aging of existing auto-transformers)*

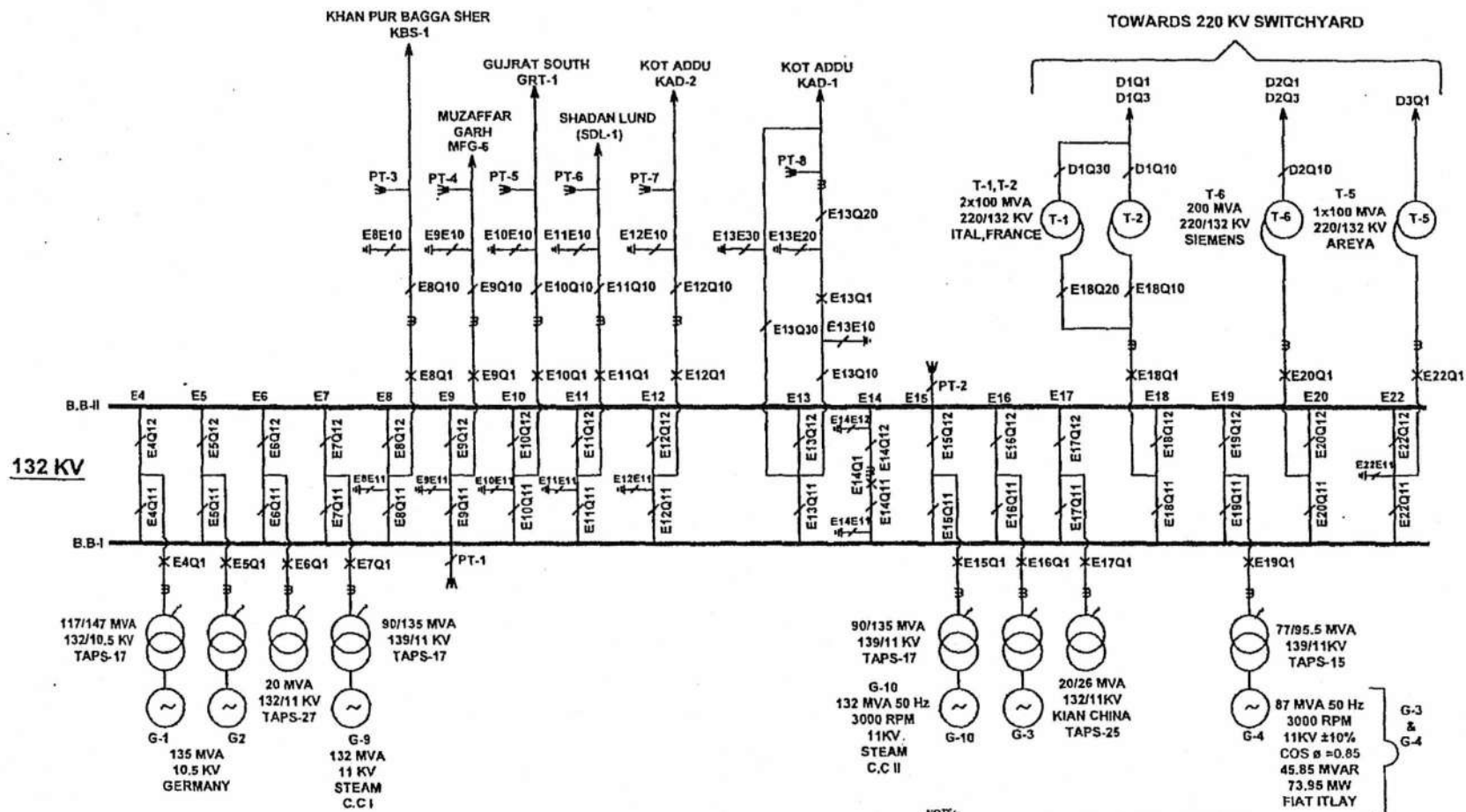
NOTE: This verified updated drawing of the station(s) will be implemented after completion of modification work during the shutdown at the station(s). The **ISOLATION** and **RESTORATION** switching for the shutdown will be carried out according to **EXISTING** and **VERIFIED UPDATED NEW** drawing respectively.


Addl: Chief Engineer (RCC(N),
NPCC, NTDC, Islamabad.

Copy for information:

- General Manager (Power Planning), NTDC, Lahore.
- CTO, CPPA-G, Islamabad
- Chief Engineer substation Design, NTDC, 143-WAPDA house Lahore.
- Chief Engineer (System Protection), NTDC, Lahore
- Director RCC (South), Jamshoro.
- Deputy Director (S/D), NCC, Islamabad
- Deputy Director (SCADA) NPCC, Islamabad.





NOTE:- AVAILABLE C.T RATIOS ON 132 KV SIDE ARE 1400/100/400/1

DRAWN BY. A.D.M	NATIONAL POWER CONTROL CENTRE (NTDC)
CHECKED BY. A.D (Drawing)	132 KV SWITCH YARD
CHECKED BY. Dy.Dir (RCCN)	KOT ADDU P/H
APPROVED BY. Addl.C.E (RCCN)	DATE: 26-03-2021
	IPP
	REV: 10

ANNEXURE G
GENERATION LICENSE



Registrar

National Electric Power Regulatory Authority

Islamic Republic of Pakistan

2nd Floor, OPF Building, G-5/2, Islamabad.

Ph : 9207200 Ext : 330 — Fax : 9210215

E-mail : office@nepra.org.pk

Direct Phone : (051) 9206500

No. NEPRA/R/LAG-18/11670-71

22-9-2004

Chief Executive Officer,
M/s. Kot Addu Power Company Ltd.
Kot Addu Gas Turbine Power Station,
District Muzaffargarh (PC 34060),

Subject: **Grant of Generation Licence IPGL/020/2004**
Licence Application No. LAG - 18
M/s. Kot Addu Power Company Ltd.

Please refer to your application No. nil, dated 17.06.2002 for a Generation Licence.

2. Enclosed here is Generation Licence No. IPGL/020/2004 granted by the Authority to M/s. Kot Addu Power Company Ltd. The Licence is granted to you pursuant to Section 15 of the Regulation of Generation, Transmission and Distribution of Electric Power Act (XL of 1997).

3. Please quote above mentioned Generation Licence No. in your future correspondence with the Authority.

DA/As above.



22-9-04.
(Mahjoob Ahmad Mirza)

Copy for information to Director General, Pakistan Environmental Protection Agency,
44-E, Office Tower, Blue Area, Islamabad.

National Electric Power Regulatory Authority
(NEPRA)
Islamabad - Pakistan

GENERATION LICENCE

No. IPGL/020/2004

In exercise of the Powers conferred upon the National Electric Power Regulatory Authority (NEPRA) under Section 15 of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997 (XL of 1997), the Authority hereby grants a Generation Licence to:

Kot Addu Power Company Limited

Incorporated under the Companies Ordinance, 1984

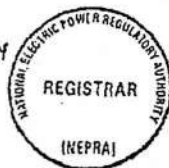
Under Certificate of Incorporation

No. 1-01977 Dated 25th April 1996

to engage in generation business subject to and in accordance with the Articles of this Licence.

Given under my hand this 22nd day of September, Two Thousand & Four, and expires on 21st day of September, Two Thousand & Twenty One.

22.09.04
Registrar



[Handwritten signature]



Registrar

National Electric Power Regulatory Authority
Islamic Republic of Pakistan

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/R/LAG-18/7064-71

September 08, 2022

Mr. Aftab Mahmood Butt
Chief Executive
Kot Addu Power Company Limited
5 B/3, Gulberg-III, Lahore

Subject: Renewal of Generation Licence No. IPGL/020/2004
Licence Application No. LAG-18
Kot Addu Power Company Limited (KAPCO)

Reference: KAPCO letter No. KAPCO/CEO/2021/423 dated 24.06.2021

It is intimated that the Authority has approved renewal in Generation Licence No. IPGL/020/2004 dated September 22, 2004 in respect of Kot Addu Power Company Limited (KAPCO) pursuant to Section 26 of the NEPRA Act read with Rule-5(2) of the NEPRA Licensing (Generation) Rules, 2000.

2. Enclosed please find herewith determination of the Authority in the matter of Renewal of Generation Licence No. IPGL/020/2004 dated September 22, 2004 granted to KAPCO.

Enclosure: As Above



08 09 22
(Syed Safeer Hussain)

Copy to:

1. Secretary, Power Division, Ministry of Energy, 'A' Block, Pak Secretariat, Islamabad
2. Managing Director, Private Power & Infrastructure Board (PPIB), Ground & 2nd Floors, Emigration Tower, Plot No. 10, Mauve Area, Sector G-8/1, Islamabad
3. Managing Director, NTDC, 414 WAPDA House, Lahore
4. Chief Executive Officer, CPPA(G), 73 East, A.K. Fazl-ul-Haq Road, Blue Area, Islamabad
5. General Manager, National Power Control Centre (NPCC – NTDC), Faiz Ahmed Faiz Road, H-8/1, Islamabad
6. Chief Executive Officer, Multan Electric Power Company, MEPCO Headquarters, Khanewal Road, Multan
7. Director General, Environmental Protection Department, Government of the Punjab, National Hockey Stadium, Ferozpur Road, Lahore

**National Electric Power Regulatory Authority
(NEPRA)**

Islamabad – Pakistan

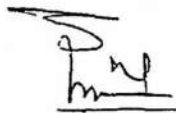
GENERATION LICENCE

IPGL/020/2004

In exercise of the powers conferred under Section-26 of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997, as amended or replaced from time to time read with Rule-5(2) of the NEPRA Licensing (Generation) Rules, 2000, the Authority hereby renews the Generation Licence [No. IPGL/020/2004 dated September 22, 2004] granted to KOT ADDU POWER COMPANY LIMITED to the extent mentioned as here under:-

- (a). The expiry date mentioned in **Face Sheet** of the original **Generation Licence** has been changed from **September 21, 2021** to **September 21, 2024**; and
- (b). The **Term** of Licence mentioned in **Article-4** of the original Generation Licence may be considered as **twenty (20) years**;
- (c). In **Article-5** of the Generation Licence, **NEPRA (Fee) Rules, 2002** may be replaced with **NEPRA (Fees) Regulations, 2021**;

This Renewal/Extension in Generation Licence is given under my hand on 8th day of September Two Thousand & Twenty Two


08 09 22
Registrar







ANNEXURE H

PROVISIONAL TARIFF



Registrar

National Electric Power Regulatory Authority Islamic Republic of Pakistan

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-600/KAPCO-2023/ 20646-50

August 04, 2023

Subject: Decision of the Authority in the matter of Grant of Provisional Tariff requested by Kot Addu Power Company Limited. [CASE NO. NEPRA/TRF-600/KAPCO-2023]

Dear Sir,

Please find enclosed herewith the subject decision of the Authority (total 06 Pages) along with Opinion of Mr. Rafique Ahmad Shaikh, Member NEPRA regarding grant of Provisional tariff requested by Kot Addu Power Company Limited. [Case No. NEPRA/TRF-600/KAPCO-2023].

2. The Decision 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 within 30 days from the intimation of this Decision. In the event the Federal Government fails to notify the subject tariff Decision or refer the matter to the Authority for reconsideration, within the time period specified in Section 31(7), then the Authority shall notify the same in the official Gazette pursuant to Section 31(7) of NEPRA Act.

Enclosure: As above

(Engr. Mazhar Iqbal Ranjha)

Secretary
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
3. Chief Executive Officer, Central Power Purchasing Agency Guarantee Limited (CPPA-G) Shaheen Plaza, 73-West, Fazl-e-Haq Road, Islamabad
4. Chief Executive Officer, Kot Addu Power Co. Ltd. (KAPCO) 5-B/3, Gulberg-III, Lahore, Tele: 042 - 3577 2912 - 19



**DECISION OF THE AUTHORITY IN THE MATTER OF GRANT OF
PROVISIONAL TARIFF REQUESTED BY KOT ADDU POWER COMPANY
LIMITED.**

BACKGROUND

1. Kot Addu Power Company Limited (hereinafter refer as "KAPCO") was incorporated on April 25, 1996, as a public limited company under the companies Ordinance, 1984 for purpose of acquiring, operating and maintaining multi-fuel based generation facility/combined cycle thermal power plant, located at Kot Addu, District Muzaffargarh, Punjab. KAPCO has been operating and maintaining the power project for more than 25 years. The project comprises of generation facility that was divided into three (3) energy blocks, with each having a combination of gas and steam turbines and a switchyard facility. However, the project is now classified into: Plant 1, Plant 2 and switchyard facility connecting to 12 transmission lines and 4 autotransformers at 132kV/220kV levels ("Switchyard Facility").
2. The Authority granted Generation License (No. PGL/020/2004 dated September 22, 2004) to KAPCO for a period of 17 years which expired on September 21, 2021. KAPCO requested for extension of its Generation License and the Authority vide its determination dated September 8, 2022 extended the term of its Generation License upto September 21, 2024 i.e. for the period of three (3) years.
3. KAPCO entered into a Power Purchase Agreement (PPA) with WAPDA for sale of electric power from its 1600 MW multi-fuel based thermal generation facility. The said PPA was for a period of 25 years commencing from June 27, 1996 which expired on June 26, 2021. The PPA was novated to CPPA-G on February 15, 2021 as a Power Purchaser. As per third (3rd) amendment in PPA dated February 11, 2021 signed between KAPCO and WAPDA the term of PPA was extended for 485 days effective from June 27, 2021 which expired on October 24, 2022.
4. KAPCO has submitted petition for determination of reference generation tariff for its 1600 MW (ISO) and Net Dependable Capacity (RSC) of 1345 MW thermal power generation facility and switchyard charges for five years from October 25, 2022. The requested tariff is reproduced hereunder:



Fuel	Energy Blocks	Energy Purchase Price	Capacity Purchase Price @30% Load Factor	Total Reference Tariff
		PKR/kWh	PKR/kWh	PKR/kWh
Plant 1				
Gas/RLNG	Block I	28.4578	5.2936	33.7514
	Block IIA	30.6851		35.9787
	Block IIB	30.1558		35.4494
LSFO	Block I	23.4265	5.3784	28.8049
	Block IIA	24.9567		30.3351
	Block IIB	24.5277		29.9061

Handwritten signature/initials



*Provisional Approval of Interim Tariff for Kot Addu Power Company Ltd
Case No. NEPRA/TRF-600/KAPCO-2023*

HSD	Block I	64.3231	5.3589	69.6820
	Block IIA	69.3862		74.7451
	Block IIB	68.6640		74.0229
Plant 2				
Gas/RLNG	Block IIC	30.3166	4.7231	35.0397
	Block III	32.0890		36.8121
LSFO	Block IIC	24.8629	4.6736	29.5365
	Block III	No provision on LSFO		
HSD	Block IIC	68.8500	4.8306	73.6806
	Block III	72.4878		77.3184



5. KAPCO has requested two part tariff i.e. energy component and capacity component for Plant 1 on 'Take or Pay' basis and for Plant 2 on 'Take and Pay' basis. Similarly, the petitioner also requested two part switchyard tariff comprising energy transformation charges of Rs. 0.0512/kWh and fixed charges of Rs. 219.2581/kW/Month.

REQUEST FOR INTERIM TARIFF

6. Pursuant to Rule 4(7) of the National Electric Power Regulatory Authority (Tariff Standards and Procedure) Rules, 1998, the Petitioner also requested the Authority to grant a provisional approval of tariff, allowing the Petitioner to supply power from generation facility to power purchaser and making the switchyard facility available, during period commencing from the date of determination of provisional tariff till the time the Authority arrives at its final determination.
7. As per the KAPCO, despite the generation facility not being operational since the expiry of the original PPA, due to repeated insistence of National Transmission & Despatch Company Limited ("NTDC") and directives of the Ministry of Energy, Power Division ("MOE"), the switchyard facility is being made available by KAPCO to NTDC. The Generation facility ran as a base load plant and played a crucial role in supply of power to the local areas of Multan Electric Power Company ("MEPCO"), Peshawar Electric Supply Company ("PESCO") and Faisalabad Electric Supply Company ("FESCO"). In the absence of a tariff, the petitioner cannot continue to play this crucial role in the supply of power the aforementioned distribution companies.
8. KAPCO submitted in its petition that NTDC has also written a letter to KAPCO, pursuant to a meeting held at MoE, regarding the expiry of the original PPA which was attended by representatives of MoE, NTDC and CPPA-G. Based on meeting discussion, NTDC through letter requested to KAPCO to "ensure the availability of its 220/132kV switchyard and other ancillary services after expiry of its PPA on October 21, 2022 at 24:00Hrs."
9. KAPCO further submitted that the facility also has a major role in the supply of electricity in emergency situations. It has a black-start facility (the "Black-start Facility") to support the system in case of country-wide blackout. NTDC also wrote a letter dated January 25, 2023 to the Petitioner in which it recognized the effectiveness of the Facility and its support for system restoration by using the Black-start Facility. NTDC, through the same letter, advised the

note in 2



Petitioner and the Power Purchaser to expedite the process of entering into a power purchase agreement so that the Petitioner can carry on its services.

10. Another reason for issuance of the Provisional Tariff Approval, as per the petitioner, is the impending summer season as there is overloading of the auto transformers due to the growing need of electricity.

ANALYSIS ON THE REQUEST FOR INTERIM TARIFF

11. The request of immediate application of proposed tariff under Rule 4(7) has been examined. Rule 4(7) is reproduced as under:

"The Authority may, while admitting a petition, allow the immediate application of the proposed tariff subject to an order for refund for the protection of consumers, or for satisfactory security to be provided for refund, while the proceedings are pending before the Authority."

12. The Authority has also considered Section 5.2 of the approved IGCEP, pertaining to the assumptions of IGCEP. The assumption regarding KAPCO as per the IGCEP is as under:

"Minimum Despatch of 500 MW from Existing KAPCO CCPP (Block-I and Block-II) in the months of May to September uptill year 2025 has been considered, beyond its PPA expiry i.e., Oct. 2022, owing to network requirements/constraints, whereas, the remaining capacity (Block-III) has been retired as per PPA expiry. It is pertinent to mention that the requirement of KAPCO beyond its PPA expiry will be assessed in ongoing Transmission System Expansion Plan (TSEP), accordingly competent forum will be approached, after consensus among concerned stakeholders i.e., NTDC, CPPAG and KAPCO, for PPA extension or otherwise and the same will be considered in next iteration of IGCEP."

13. The Authority also observed that NTDC Board in its 236th meeting held on November 28, 2022 approved retention of 500 MW capacity from KAPCO i.e. Block I connected with 220 kV system and Block II only GTs & STs connected with 132 kV system. The net dependable capacity of these systems/units is 645 MW comprising 347 MW for block I and 298 for block II connected with 132 kV. The combined PAP submitted by DISCOs in April 2023 also include only 500 MW from KAPCO.
14. The Authority noted that as per the NEPRA Act, for determination of tariff, a minimum period of four months is provided. Since PPA has expired and there is no tariff in the field, the power plant cannot be despatched even if need arises (on constraints basis or as per merit order) otherwise a payment dispute will emerge.
15. In view of above discussion, the Authority has decided to accept the request of KAPCO for allowing provisional tariff under Rule 4(7) of NEPRA Tariff (Standards and Procedure) Rules, 1998, subject to final decision and order of refund, if any, for the protection of the consumers while the proceedings are pending before the Authority.





ORDER

16. Based on the documentary evidence and information provided by KAPCO, the Authority acceded the request of KAPCO and approves, under Rule 4(7) of the Tariff Standards & Procedure Rules -1998, provisional tariff on 'take and pay' basis at 80% availability factor on Gas/RLNG and LSFO (no HSD), subject to final decision and order of refund, if any, for the protection of the consumers while the proceedings are pending before the Authority.
17. The Allowed a provisional tariff is for a total capacity of 500 MW of Block-1 connected to 220 kV and Block-2 connected to 132 kV. The despatch shall be on economic merit order with no must-run despatch.

Components	Block	Allowed Tariff Rs./kWh
Fuel Cost Component Gas/RLNG	I	26.8647
	II	29.4660
Fuel Cost Component LSFO	I	21.1214
	II	23.1810
Fuel Cost Component HSD	I	-
	II	-
VO&M Gas/RLNG	I	0.6357
	II	0.6340
VO&M LSFO	I	1.1027
	II	1.3643
Fixed O&M Gas/RLNG	I,II	0.4232
Fixed O&M LSFO	I,II	0.4395
Cost of Working Capital Gas/RLNG	I,II	0.4183
Cost of Working Capital LSFO	I,II	0.3899
ROE Gas/RLNG	I,II	0.3388
ROE LSFO	I,II	0.3519
Total Gas/RLNG	I	28.6807
	II	31.2804
Total LSFO	I	23.4053
	II	25.7266



18. The application of provisional tariff shall be subject to following conditions:
- Tariff shall be on Take & Pay basis.
 - The fuel cost components have been worked out on the basis of LSFO Price of Rs.111,047.93/Ton including transportation charges and Gas/RLNG price of Rs.3,381.50/MMBTU (Rs.10,722.08/Hundred m3). The fuel cost component(s) shall be subject to adjustment for variation in fuel price(s).
 - The despatch shall be strictly in accordance with the economic merit order with no must-run despatch.
19. The above provisional tariff shall take effect from the date of issuance of the instant decision.



NOTIFICATION

20. The above Order of the Authority is to be notified in the Official Gazette in accordance with the provision of Section 31(7) of the Regulation of Generation, Transmission and Distribution of Electric Power Act 1997.

AUTHORITY

Mathar Niaz Rana

Mathar Niaz Rana (nsc)
Member

Engr. Maqsood Anwar Khan

Engr. Maqsood Anwar Khan
Member

My opinion is attached.
Rafique Ahmed Shaikh

Engr. Rafique Ahmed Shaikh
Member

Amina Ahmed
Member

Tauseef H. Farooqi
Chairman



9/8/23

Opinion of Member Technical

Tariff on "Take & Pay" basis as allowed shall be given as "Merchant Plant" and in case of operation of plant out of merit, the difference in cost should be borne by the responsible agency i.e. NTDC/NPCC not the consumers for reasons that:

- a) The planning of transmission system and removal of constraints is the job of NTDC;
- b) And the constraints as mentioned by NTDC are controllable and can be managed through governance and planning.

[Handwritten Signature]
02/06/23



ANNEXURE I

APPROVED IGCEP 2022-2031

18. Only Shaitaj is taken as a committed project from Category-I and II bagasse-based projects since it has been awarded revised tariff by NEPRA. Further, yearly candidate block of 100 MW bagasse has been considered from the year 2024-25 onwards.
19. 370 MW_p of net metering is considered for NTDC System each year.
20. Candidate hydro power projects under 20 MW and connected below 132 kV (and hence, not in central dispatch) have not been considered.
21. No candidate thermal or RE projects have been considered by name.
22. Siddiqsons CFPP has been removed from the list of committed projects, due to LOS expiry and presently under litigation as per PPIB.
23. Gwadar CFPP has been considered on Local Coal as conveyed by relevant project executing agency, i.e., PPIB.
24. The COD of CASA has been assumed as August 2024.
25. Diamer Bhasha HPP has been delayed beyond the study horizon of the current version of IGCEP owing to the progress made so far by the project, as decided in a meeting held at MoE (PD), among representatives from NTDC, PPIB, MoE (PD), WAPDA and MoW&R.
26. Existing Engro Powergen CCPP has been modelled as per data provided by M/s Engro CCPP representative in view of its Gas Depletion Mitigation Plan (GDMP). It is to highlight that minimum take or pay dispatch of 50% on the available yearly Permeable gas has been considered.
27. Pursuant to approved NE Policy 2021, K-Electric system has also been included in the current version of IGCEP.
28. For candidate local coal-based projects, the fixed fuel cost component (FFCC) of 11.2 \$/Ton (71.821 \$/kW-year) and fuel price of 9.97 \$/Ton (0.88 \$/GJ) have been considered as per TCEB determination of 2020 pertaining to Thar Block-II at 30.8 MTPA.
29. In order to cater for network requirements/constraints, some existing projects located near load center have been considered as "Must Run", for summer months, i.e., May to September up till year 2025.
30. Minimum Dispatch of 500 MW from Existing KAPCO CCPP (Block-I and Block-II) in the months of May to September up till year 2025 has been considered, beyond its PPA expiry i.e., Oct. 2022, owing to network requirements/constraints, whereas, the remaining capacity (Block-III) has been retired as per PPA expiry. It is pertinent to mention that the requirement of KAPCO beyond its PPA expiry will be assessed in ongoing Transmission System Expansion Plan (TSEP), accordingly competent forum will be approached, after consensus among concerned stakeholders i.e., NTDC, CPPA-G and KAPCO, for PPA extension or otherwise and the same will be considered in next iteration of IGCEP.
31. 140 MW Habibullah Costal (HCPC) and 31 MW Altern Energy Limited (AEL) have not been considered in the existing installed capacity owing to termination of Gas Supply Agreement (GSA) and de-licensing by NEPRA, respectively.
32. The COD of a committed project i.e., 84 MW Gorkin Maliltan HPP, has been assumed as of July 2024 instead of July 2023 in view of its latest progress.
33. Following lead time criterion for the candidate power projects has been assumed:

Indicative Generation Capacity Expansion Plan (IGCEP) 2022-31

IGCEP 2022-31 is provided in the Table 5-2. For the purpose of the IGCEP, a power project stands retired either as per its PPA/EPA term or relevant CCoE decision. Major retirement of generation capacity for the IGCEP 2022-31 corresponds to RFO based power projects, followed by Local Gas and then RLNG based power projects.

Table 5-2: Retirement Schedule of Power Projects in the Existing NTDC System

Sr. #	Name of the Power Station	Installed Capacity (MW)	Fuel Type	Retirement Year (FY)						Rationale
				23	26	27	29	30	31	
1	Guddu-II U (5-10)	620	Gas	✓						CCoE decision
2	Jamshoro-I U1	250	RFO	✓						
3	Jamshoro-II U4	200	RFO	✓						
4	Muzaffargarh-I U1	210	RFO	✓						
5	Muzaffargarh-I U2	210	RFO	✓						
6	Muzaffargarh-I U3	210	RFO	✓						
7	Muzaffargarh-II U4	320	RFO	✓						
8	KAPCO 1	400	RLNG		✓					PPA extended owing to network constraints*
9	KAPCO 2	900	RLNG		✓					
10	KAPCO 3	300	RLNG	✓						PPA expiry
11	Liberty	225	Gas			✓				
12	HUBCO	1,292	RFO			✓				
13	Kohinoor	131	RFO			✓				
14	AES Lalpir	362	RFO				✓			
15	AES Pakgen	365	RFO				✓			
16	FKPCL	172	RLNG					✓		
17	Saba	136	RFO					✓		
18	Uch	586	Gas						✓	
19	Rousch	450	RLNG						✓	
Total (MW)				7,339						

Note: *A sensitivity analysis to assess the requirement of existing KAPCO CCPP beyond its PPA expiry, in years to come will be conducted in the on-going Transmission System Expansion Plan (TSEP). However, considering the historical dispatch of KAPCO owing to network constraints in the region, two blocks of KAPCO have been assumed to stay in system up till the year 2026.

The retirement plan of K-Electric system is shown in Table 5-3. A total of 682 MW capacity is going to be retired from K-E system in the upcoming years.

ANNEXURE J

COPY OF IGCEP 2024-2034

System operator has submitted updated IGCEP 2024-34 wherein KAPCO has been retained in the system till June 2027 as per system requirement, copy of relevant page is enclosed below:

5.2. Retirement of Existing Power Projects

A significant quantum i.e 8,330 MW of the existing thermal power projects are scheduled to be retired from NTDC system during the planning horizon of the IGCEP 2024. The retirement schedule for the IGCEP 2024-34 is provided in the Table 5-2. For the purpose of the IGCEP, a power project stands retired as per its PPA/EPA term. Major retirement of generation capacity for the IGCEP 2024-34 corresponds to RFO based power projects, followed by Local Gas and then RLNG based power projects.

Table 5-2: Retirement Schedule of Power Projects in the Existing System

Sr. #	Name of Power Station	Installed Capacity (MW)	Fuel Type	Retirement Year (FY)										Rationale
				24	25	27	28	29	30	31	33	34		
NTDC System														
1	Jamshoro-I U1	250	RFO					✓						GENCOs Retirements
2	Jamshoro-II U4	200	RFO					✓						
3	Muzaffargarh-I U1	210	RFO										✓	
4	Muzaffargarh-I U2	210	RFO										✓	
5	Muzaffargarh-I U3	210	RFO										✓	
6	Muzaffargarh-II U4	320	RFO										✓	
7	Guddu-II U	620	Gas										✓	
8	KAPCO*	1300	RLNG			✓								Network constraints
9	Liberty	235	Gas				✓							PPA expiry
10	HUBCO	1,292	RFO			✓								
11	Kohinoor	131	RFO			✓								
12	AES Lalpir	362	RFO					✓						
13	AES Pakgen	365	RFO					✓						
14	FKPCL	157	RLNG							✓				
15	Saba	136	RFO						✓					
16	Uch	586	Gas							✓				
17	Roush	450	RLNG								✓			
18	Altern Energy Limited	31	RLNG						✓					
19	AGL	163	RFO										✓	
Total (MW)		7,228												
K-Electric System														
20	BQPS1-U1	210	RLNG		✓									PPA expiry
21	BQPS1-U2	210	RLNG		✓									
22	BQPS1-U5	210	RLNG			✓								
23	BQPS1-U6	210	RLNG									✓		
24	GAEL	136	RFO		✓									

ANNEXURE K

NPCC LETTER DATED 22.05.2024

GM (System Operation) NPCC vide their letter no 7040-45/GM (SO)/NPCC/DDPC-1/CPPAG dated May 22, 2024 to CPPA-G, copy of which is enclosed below:



National Transmission & Despatch Company Ltd.
General Manager (System Operation) NPCC

No: 7040-45 /GM(SO)/NPCC/DDPC-1/

Dated: 22-05-2024

Chief Financial Officer
CPPA-G, Plot No. 73, Fazal ul Haq Rd,
Blue Area, Shaheen Plaza, Islamabad

**Subject: PPA RENEWAL-OVERLOADING OF AUTO TRANSFORMERS
INSTALLED AT KAPCO**

Ref: 1.GM KAPCO Letter No. KCW/2505/01 Dated: 10.05.2024.
2.GM KAPCO Letter No. KCW/2504/01 Dated: 06.05.2024.

With reference to above, it is apprised that the load on Auto Transformers installed at KAPCO Grid has increased up to 80% of rated capacity with the increase in ambient temperature. It is pertinent to mention here that the Auto Transformers T-1 & T-2 installed at KAPCO are in operation for 40 years and overloading may adversely impact their life. Moreover, without additional generation from 132KV side, any tripping of Grid may result in severe load congestion in the region.

Furthermore, KAPCO power plant is important due to its strategic location, multi-fuel capability and ancillary services including black-start facility. The availability of KAPCO switchyard and generation supports smooth operation of 220/132 kV network for continuity of power evacuation to MEPCO and associated region. Non-availability of KAPCO generation would result in overloading of transformers which would be overcome through load management in the MEPCO region to ensure system stability and reliability.

In view of the aforementioned facts vis-à-vis system operation, it is requested that the status of PPA renewal may please be shared with this office so that the said matter may be addressed accordingly.



(Nasir Ahmed)

General Manager (System Operation)
NPCC, NTDCL, Islamabad

Copy To:

1. Additional Secretary A-II, MoE (Power Division), Pak Secretariat Islamabad.
2. Deputy Managing Director (SO) NPCC NTDCL, Islamabad.
3. Registrar NEPRA, NEPRA Tower, Attaturk Avenue G-5/1 Islamabad.
4. Chief Executive MEPCO, Multan.
- 5. Chief Executive KAPCO.

ANNEXURE L
RAMBOLL BROCHURE



SHAPING THE FUTURE OF ENERGY

CONSULTANCY AND DESIGN OF INTEGRATED ENERGY SOLUTIONS

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Securing an integrated energy system 4
About us 6
Our approach 8
How we work 10
World class projects 12
Covering the entire value chain 14
Digital innovation 42

RAMBOLL AT A GLANCE

15,000 EXPERTS 300 OFFICES 35 COUNTRIES

ENERGY

With security of supplies, climate change, energy efficiency and resource scarcity as top priorities on the global agenda, there is a general push towards renewables, although conventional energy will continue to play a significant role in the energy mix in the coming years. As a consultancy, Ramboll is at the forefront of addressing the green transition and offers a holistic approach to energy that supports the sector on the journey towards more sustainable solutions. Read more at: <http://ramboll.com/energy>

BUILDINGS

Buildings form a fundamental part of our lives by shaping our communities and daily activities.

For these reasons, Ramboll's design philosophy is always to make room for the human experience. As one of Europe's top 5 buildings designers with decades of experience in the global market, we create visionary, sustainable, and award-winning buildings that improve life for users and enhance the surrounding landscape.

Read more at: <http://ramboll.com/buildings>

TRANSPORT

Mobility fuels economic and social development and with 50% of the world's population now living in urban areas, efficient and reliable transport systems are essential.

To meet this need, Ramboll has been working on some of the world's largest, most innovative infrastructure projects and is the leading consultancy in the Nordic market.

We create value for transport authorities, contractors and local authorities by providing multidisciplinary technical excellence and minimising resource usage. Read more at: <http://ramboll.com/transport>

PLANNING & URBAN DESIGN

Ramboll's holistic approach to urban development encompasses strategy, planning and world class technical design services and is based on an integrated multidisciplinary skills base.

We have an extensive track record working with a number of the world's largest cities to create liveable, sustainable, and implementable urban development solutions that are fully adapted to the local context.

Read more at: <http://ramboll.com/planning-and-urban-design>

COUNTRIES WITH PERMANENT OFFICES NORDIC REGION: Denmark - Copenhagen, company head office, Finland, Greenland, Norway, Sweden EUROPE: Belgium, Cyprus, France, Germany, Italy, Netherlands, Poland, Romania, Russia, Spain, Switzerland, United Kingdom MIDDLE EAST: Kingdom of Saudi Arabia, Qatar, United Arab Emirates ASIA-PACIFIC: Australia, China, India, Indonesia, Malaysia, Myanmar, New Zealand, Singapore THE AMERICAS: Brazil, Canada, Mexico, USA AFRICA: South Africa

WATER

Water is essential to life and one of our most precious resources. Working with municipalities, utilities, and industrial clients, Ramboll draws on proven multidisciplinary expertise to manage the most challenging water resources, wastewater, and storm water issues.

We integrate treatment process selection and engineering, operational services, and regulatory management and planning to deliver innovative solutions that benefit both industries and society.

Read more at:
<http://ramboll.com/water>

ENVIRONMENT & HEALTH

As a globally recognised environmental and health consultancy, we have earned a reputation for technical and scientific excellence, innovation and client service.

Advances in science and technology and evolving regulatory, legal and social pressures create increasingly complex challenges for our clients. We evolve to keep pace with these changes - by adding new services, contributing to scientific advances or expanding geographically.

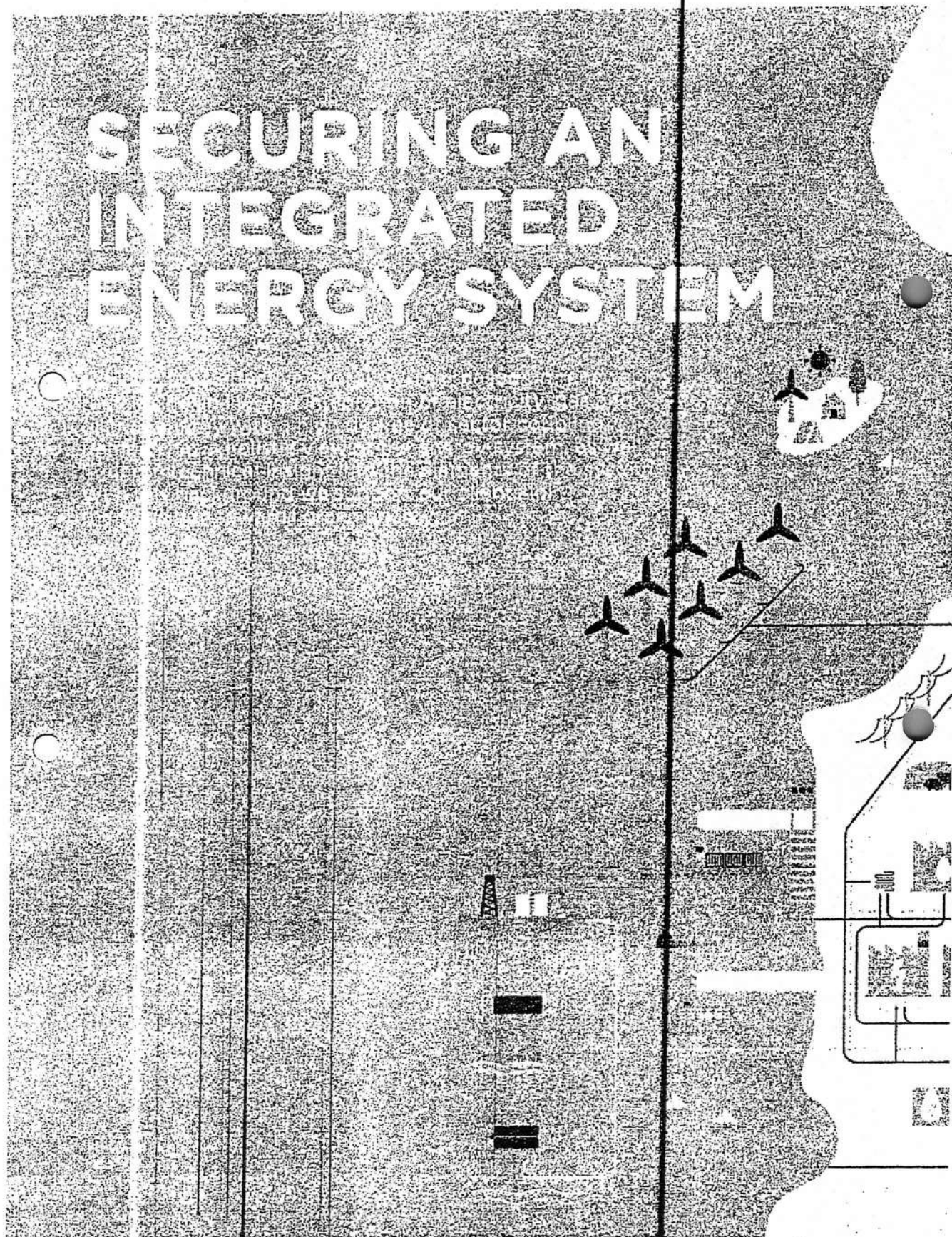
Read more at:
<http://ramboll.com/environment-and-health>

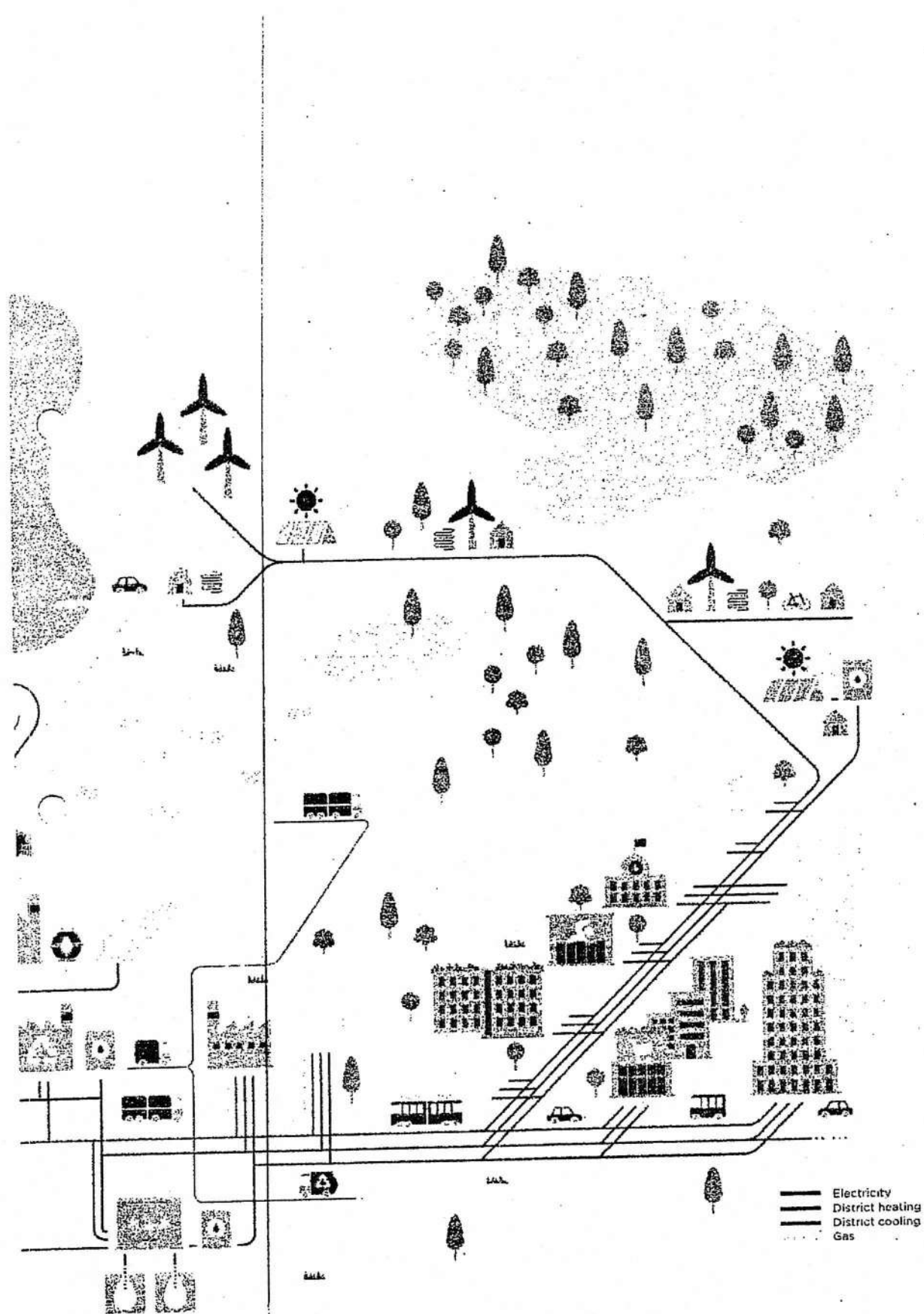
MANAGEMENT CONSULTING

National, regional and local authorities are responsible for issues that affect us all; from healthcare, education and day care to strategic planning of infrastructure and climate initiatives. Drawing on 500 management experts, Ramboll acts as a trusted partner to public administrations, creating the insights needed to make informed strategic decisions that promote stronger societies.

With unprecedented levels of competition in the global economy, Ramboll focuses on empowering private sector customers with expertise and powerful management tools. Read more at:
<http://ramboll.com/management-consulting>

SECURING AN INTEGRATED ENERGY SYSTEM





ENERGY ABOUT US

REVENUE IN 2018 EUR 163 MILLION

NUMBER OF EMPLOYEES
Ramboll Energy has approx.
1 600 specialists working
dedicatedly with renewable
and conventional energy.

GEOGRAPHICAL SPREAD
Ramboll has 55 energy offices
in 14 countries including
Denmark, Sweden, Norway, UK,
Germany, Poland, Switzerland,
USA, Canada, Qatar, UAE,
India, Singapore and China.

RANKINGS
Ramboll is ranked no. 1
in Cogeneration, no. 1 in
Towers & Antennae, no. 2 in
Hazardous waste, no. 3 in
Wind generation and no. 8
in Offshore and underwater
facilities in the ENR survey
of top international design
firms (Dec. 2018 rankings).

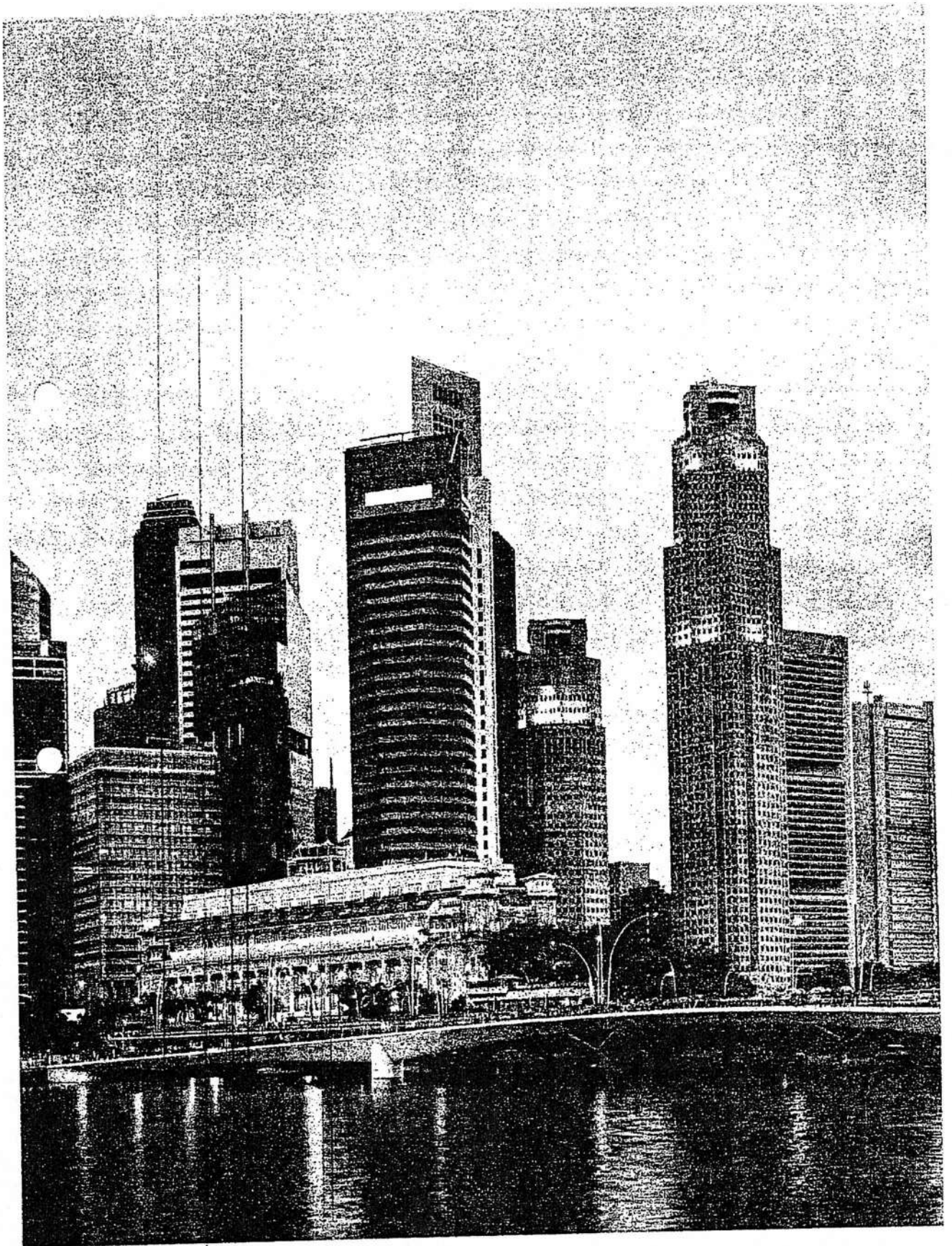
**ONE OF THE LARGEST
WASTE-TO-ENERGY
FACILITIES ON EARTH IN
ONE OF THE WORLD'S
SMALLEST COUNTRIES**
Ramboll is part of a
multidisciplinary consultancy
technical team for the planning,
design and construction
management of one of the
world's largest waste-to-
energy facilities, which will
enable Singapore to reap the
benefits of energy and resource
recovery maximisation for
years to come (image p. 7).

Ramboll has more than 50 years of experience in the planning, design and implementation of energy solutions and is among the ten leading energy consultancies in Europe. We focus on adding maximum value both to our clients and society at large through an integrated and multidisciplinary offering that cuts across the whole value chain.

The projects that we carry out for our clients typically provide the overall society benefits of securing the supply of energy, reducing climate impact, improving energy efficiency and countering resource scarcity. In this way, we contribute to a sustainable development of the energy sector.

As a people-based company, we believe that the key to our success lies in the motivation, persistence, skills and commitment of our employees. With offices around the world, we combine global knowledge with local presence. Being an international company enables us to mobilise large project teams across geographies and disciplines.

Our services are based on integrity, deep specialist insights and absolute independence of third party providers.



OUR APPROACH

○ A PARTNER FOR CHANGE

WHAT OUR CLIENTS GET

- A change partner who helps our clients think, design and implement their green energy transition
- A committed partner who takes end-to-end responsibility of our clients' projects
- A partner who listens to our clients' needs and challenges before designing the best solutions
- Proactively out-of-the-box and innovative thinking, translating ideas into pragmatic solutions
- A partner of integrity, offering independent expert consultancy
- Integrated energy solutions based on an understanding of the interaction between the different sectors and technologies, technical insight and multidisciplinary competencies
- Access to strong technical capabilities and best practice

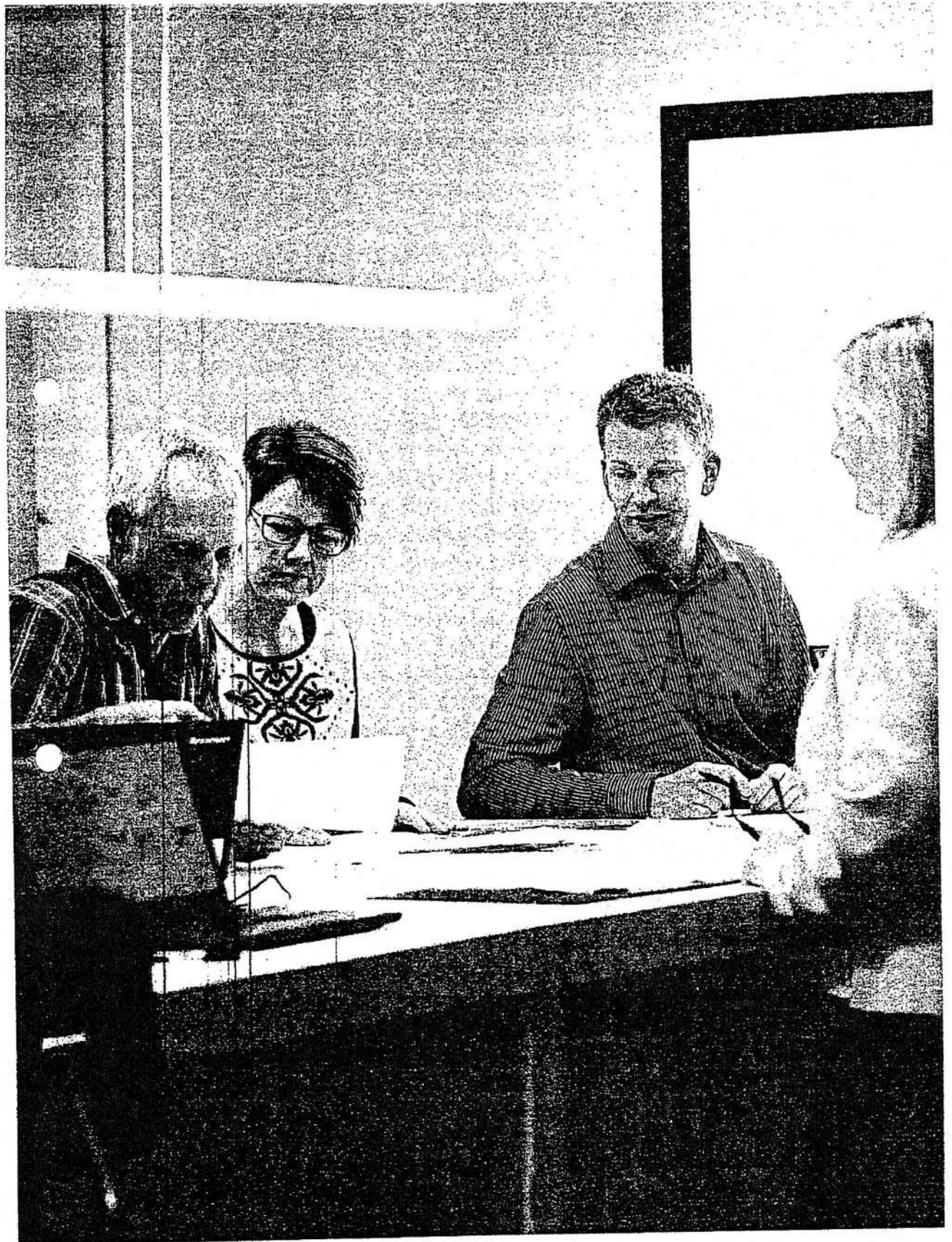
The energy sector is shifting from a system based on fossil fuels to one exploiting renewable energy. As sustainable society consultants, we bring our clients one or more steps closer to a renewable energy system, and we optimise energy efficiency, systems, technologies and processes.

We enable people and organisations to design and implement sustainable change with a lasting impact – for both business and society.

Driving green energy transition should always be built on a holistic understanding as well as in-depth expertise and experience. And it should be built on close engagement between us and our clients because no change encounter is the same, and each initiative, challenge and dialogue therefore calls for depth, creativity and perspective.

We seek long-term relationships with our clients and have worked for many of them for more than 30 years.

We are committed to guiding our clients and their organisations into a better state and to always delivering sustainable energy solutions that are innovative, integrated and flexible to suit the unique challenge at hand.



HOW WE WORK

PROJECT EXECUTION MODEL

Ramboll's ambition is to be known as the consultancy and engineering partner that sets the industry benchmark for excellence within project management. We are committed to exceeding client expectations and creating successful partnerships by consistently delivering optimised solutions, on time and within budget.

To achieve this, we have a common approach to project management across the Ramboll Group. This includes a stage gate model covering all project phases and practical tools that are based on internationally recognised standards and best practices developed by Ramboll specialists.

DELIVERING TECHNICAL EXCELLENCE

From idea to operation

We assist our clients on all aspects of a project, ranging from planning and engineering design, to long-term operation & maintenance and lifetime extension. We strive to have a close, proactive dialogue and engagement through the entire project life-cycle.

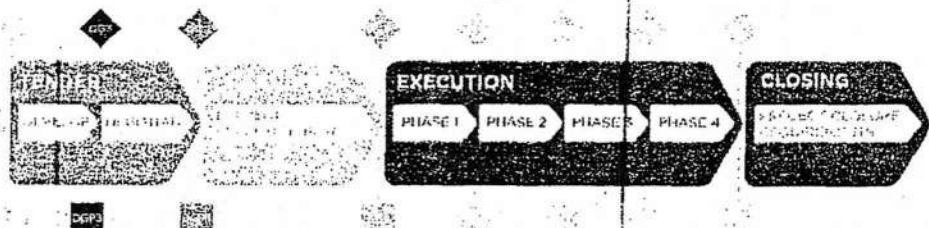
Owner's Engineers

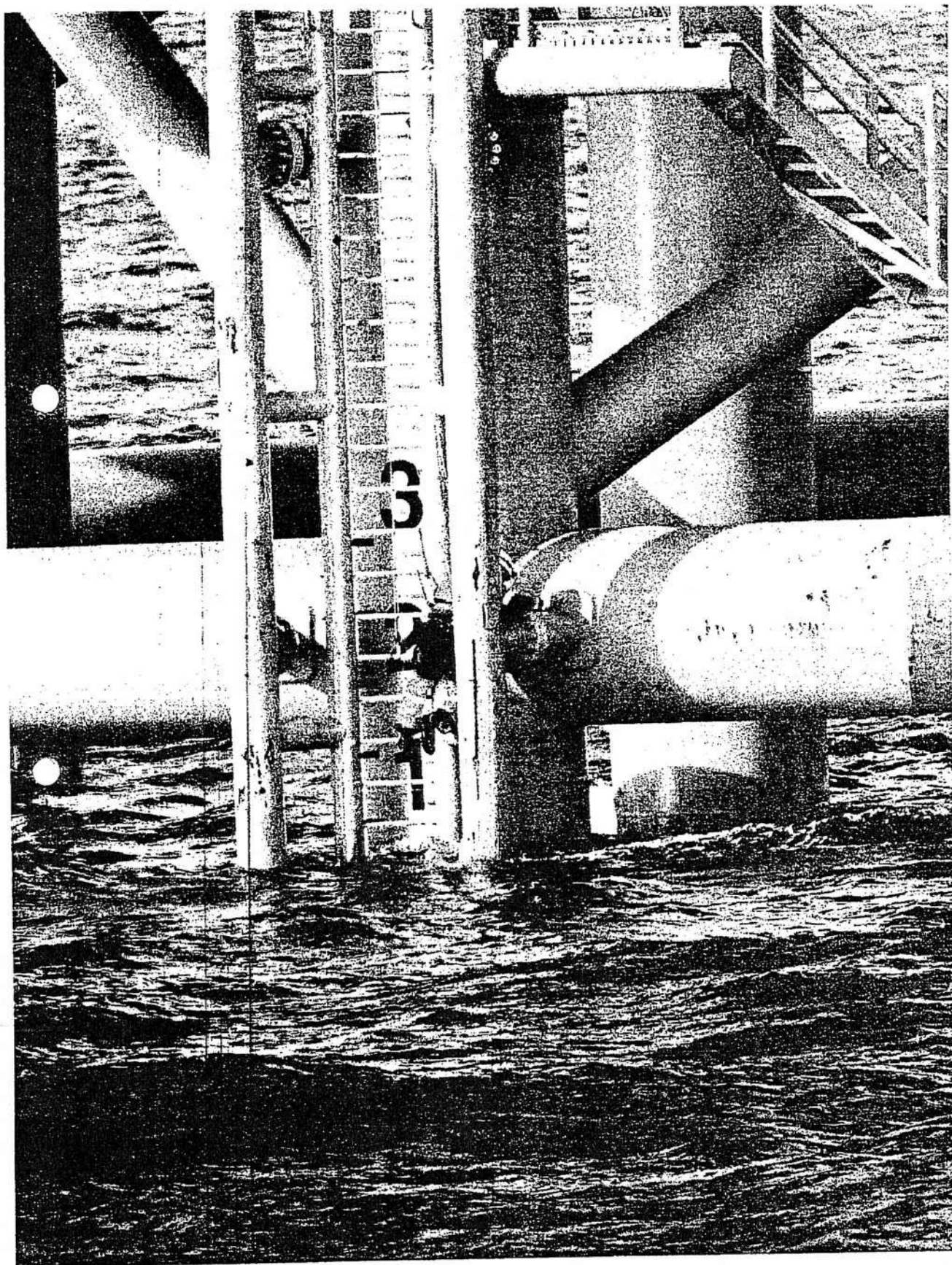
We typically act as the Owner's/ Developer's Engineer or Lead Advisor on multi-million EUR energy investment projects, assisting our clients with project management, technical expertise and engineering, while securing a solid contractual basis (commercially and technically) for the client vis-à-vis contractors/suppliers.

Unlike most other consultancies, we work both as strategic advisors and are deeply involved in the implementation phase of our projects, drawing on our hands-on experience of the operation and maintenance of energy facilities.

Strong focus on risk management

Risk management lies at the centre of our project management model and is conducted in order to anticipate possible challenges in relation to time, cost and quality. It involves the identification of risks and the proactive initiation of risk control and risk mitigation measures.





WORLD CLASS PROJECTS

**WE EXECUTE PROJECTS
OF PARAMOUNT IMPORTANCE
TO OUR CLIENTS**

**AVEDØRE POWER
PLANT, DENMARK
- ONE OF THE WORLD'S
MOST EFFICIENT MULTIFUEL
POWER PLANTS**

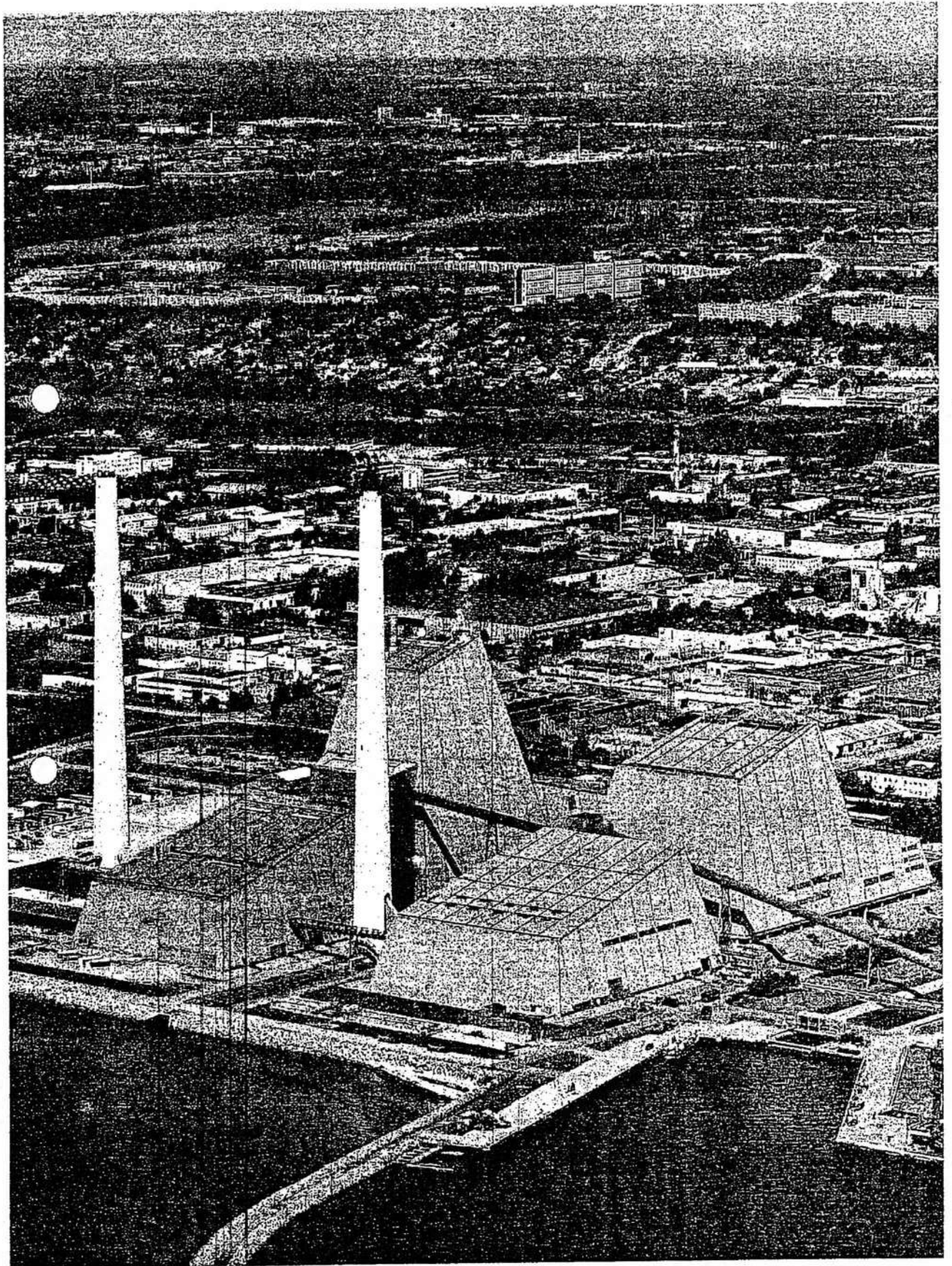
Since the conception of Avedøre Power Plant's Unit 1 in the 1980s, Ramboll has been a regular advisor to the owner, first and foremost on a wide range of specialist issues. We have contributed to the development of the plant's continuous and flexible adaptations to new fuel types leading up to today's state-of-the-art multifuel production of power and heat for Copenhagen's district heating system (in page p. 13).

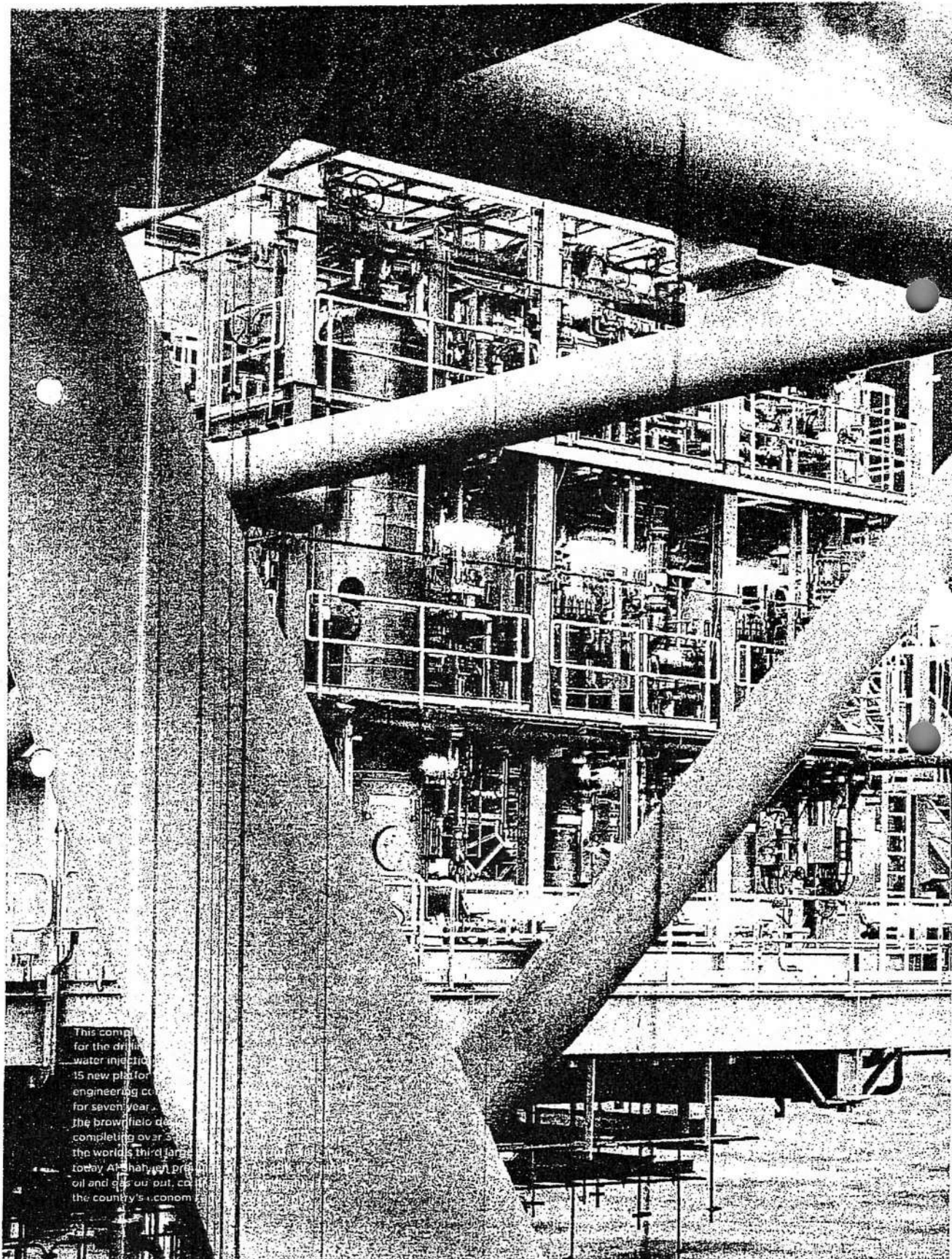
Our portfolio is unmatched by other consultancies and includes a wide range of projects developed across geographies. Each project represents a different challenge and a unique endeavour with specific requirements which demanded multidisciplinary competencies and knowledgeable management for its successful implementation.

Technology is our passion, and we maintain an unwavering engineering focus in everything we do. We are passionate about delivering world-class, high-quality solutions to our clients.

Through Ramboll's Project Excellence Platform, we bring together all aspects of project delivery and the associated enablers of continuous people development, clearly defined processes and governance, as well as effective knowledge sharing. This serves to maximise benefits for our clients by creating high value solutions, delivering project certainty, and nurturing strong and enduring relationships.

We enjoy a high client satisfaction rate as we are able to meet key success criteria such as deep technical insight and solutions tailored to our clients' requirements.





This complex
for the drilling
water injection
15 new platform
engineering co.
for seven years
the brown field de
completing over 50
the world's third large
today. At a high price
oil and gas output, co
the country's econom



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- Gas & LNG
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DRAWING ON CROSS-SECTOR AND MULTIDISCIPLINARY CAPABILITIES

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- Energy supply strategies
- Energy delivery planning and design
- Storage solutions
- Smart energy
- Energy efficiency & demand side management

BUSINESS CASES

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- Circular economy
- CAPEX, OPEX & ABEX assessments
- Lifecycle assessment ISO55000
- CBA - international best practice

POLICY

- Regulatory analysis & compliance
- Security of supply
- Market models
- Subsidies and frameworks

DUE DILIGENCE

- Commercial & financial
- Technical & operational
- Environmental assessment
- Risk assessment

Ramboll is a strategic partner to international and domestic clients offering proven commercial, financial and engineering consulting capabilities to assist our clients with the development of strategy documents, business cases, policy and due diligence studies.

We add value to projects by having full local knowledge across Europe, North America, Middle East and Asia to provide understanding of the energy lifecycle and the interaction of the different elements in the energy system.

We provide solutions to the challenges of our client: cities, universities, governments and the EU; investors; generators; transmission system operators; distribution system operators; and large consumers.

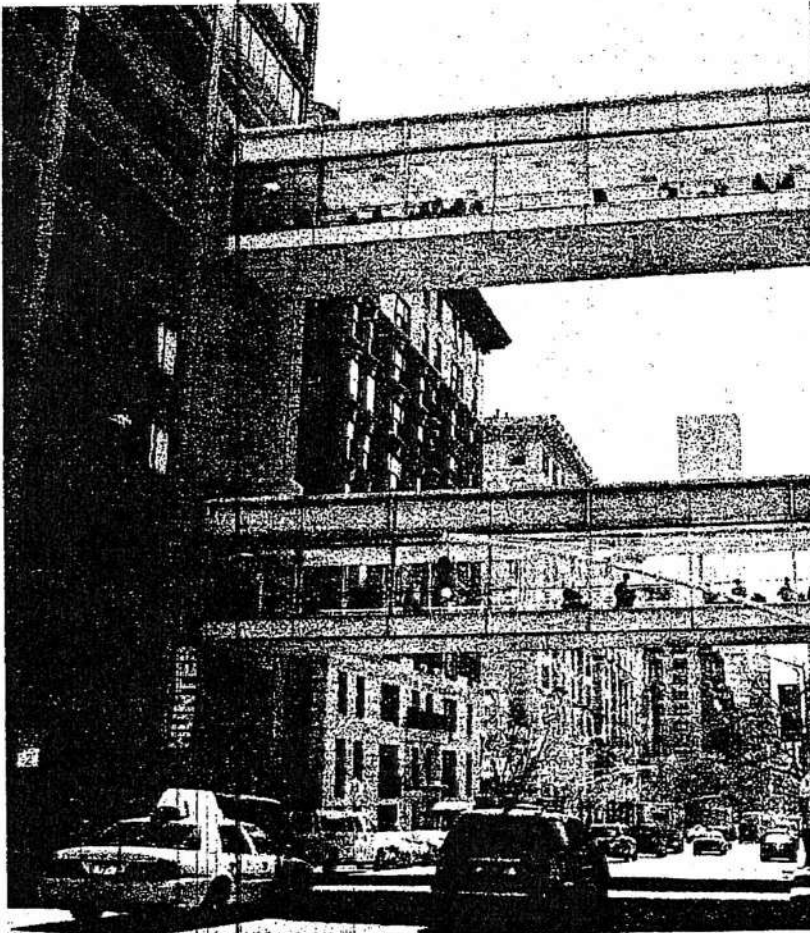
We offer a core energy strategy and planning team as the single point of contact within Ramboll for the development, execution and implementation of projects globally.

The core team draws on Ramboll expertise in 300 offices in 35 countries to offer our clients the advantage of a global platform with leading energy sector experts and local knowledge across Europe, North America, Middle East and Asia to provide the right knowledge for the right geography.

The team draws on Ramboll's multidisciplinary capabilities, e.g. within buildings, environment & health, management consulting and transport.

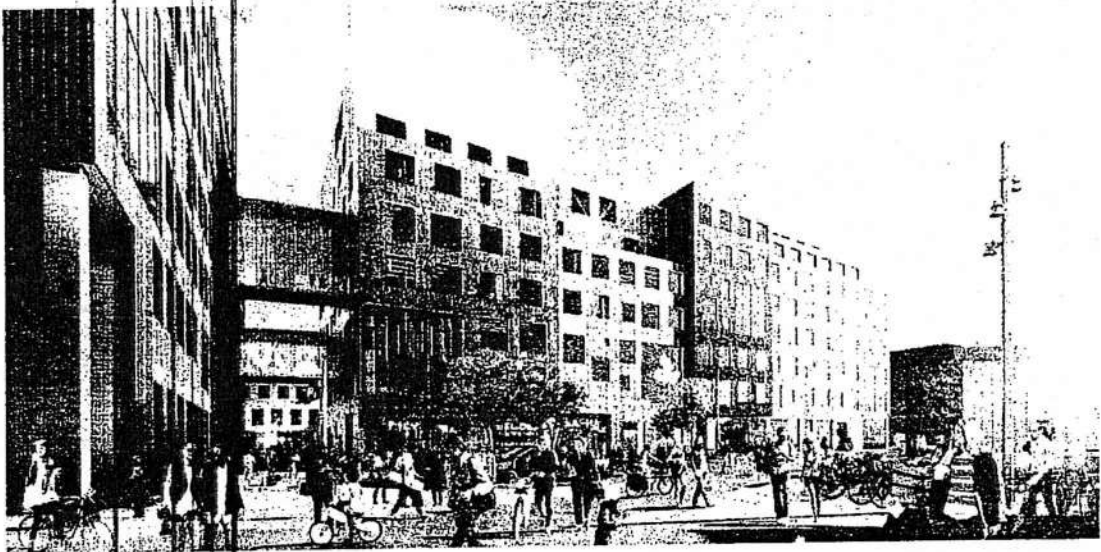
ENERGY MASTER PLANNING AT THE CITY UNIVERSITY OF NEW YORK, US

The City University of New York (CUNY) is the nation's leading urban public university. It serves over 500,000 students from 25 campuses, 300 buildings and almost 2.5 million square metres of building space, and it has an annual energy spend of nearly USD90 million. CBG, now Ramboll, has been assisting CUNY with their New York City Carbon Challenge since 2007, having developed climate action plans that identify CUNY's strategy to reduce carbon intensity by 40% by 2030.



CARLSBERG - NEW URBAN DISTRICT IN COPENHAGEN

In 2009, Carlsberg's production moved to a new site in Denmark, leaving a 350,000 m² industrial site in Copenhagen open for development. It was the vision to create a new sustainable district in Copenhagen with housing, shops and office buildings in harmony with the historical old buildings and the neighbouring districts. Ramboll planned the infrastructure with a focus on sustainable energy supply.



WIND ENERGY

OFFSHORE

Over 60% of the world's offshore wind turbines rise from foundations engineered by Ramboll.

ONSHORE

We have provided expert input to onshore wind farms with a nominal output of more than 60 GW in 80 countries.

ONSHORE WIND FARM

RASKIFTET, NORWAY

The public utility of Munich in Germany, Städtwerke München GmbH (SWM), intends to generate sufficient green energy at its plants to cover all energy consumption in Munich by 2025. As part of this endeavour, SWM has invested in several onshore and offshore wind farms in recent years, including Raskiftet Onshore Wind Farm in Norway. On behalf of SWM, Ramboll provided technical due diligence services including yield calculations and was subsequently commissioned for the supervision of the construction process as the Owner's Engineer.

OFFSHORE WIND FARM

BORKUM RIFFGRUND I

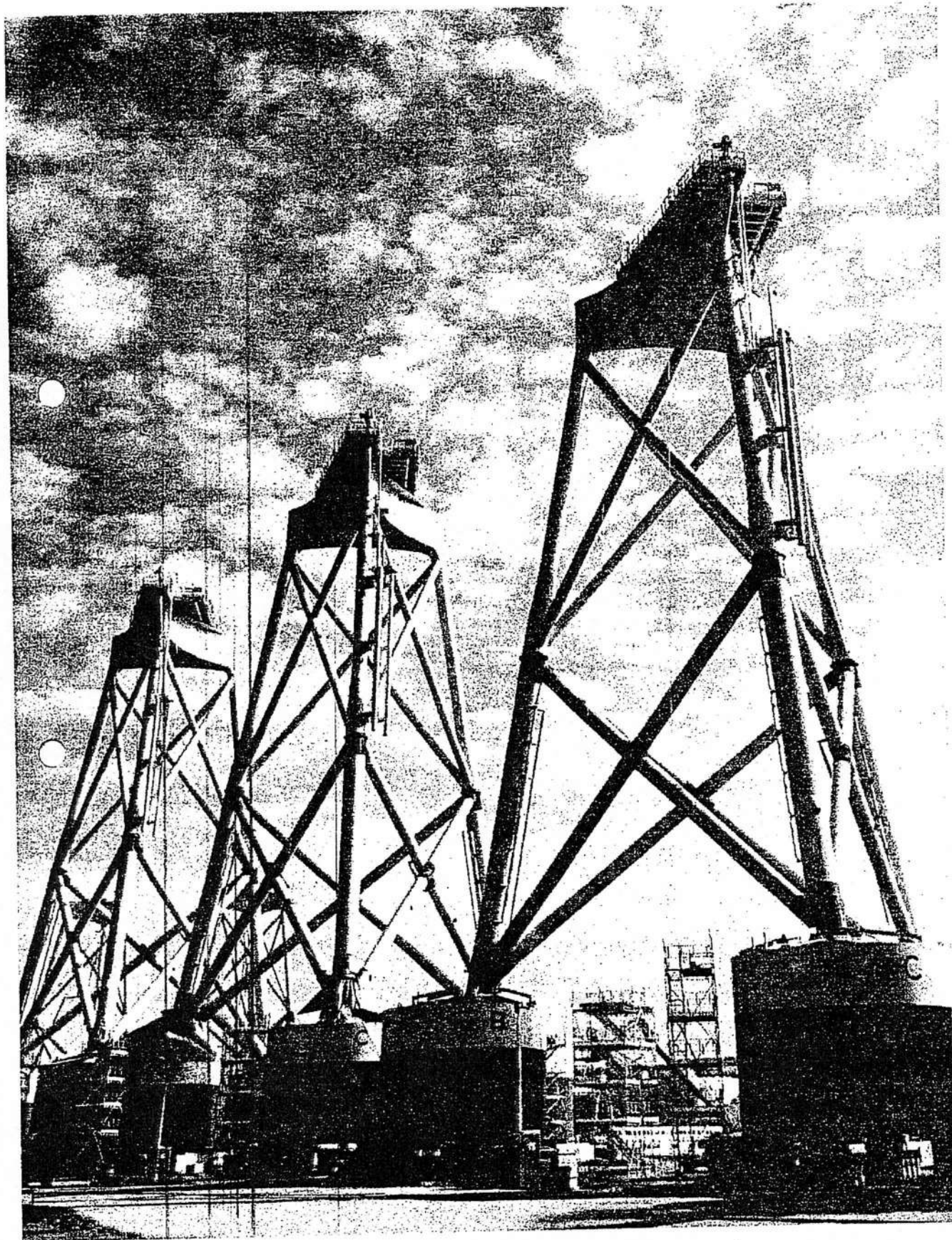
Ramboll contributed to Ørsted's successful installation of the world's first offshore wind turbine foundation based on the Suction Bucket Jacket (SBJ) technology. The scope of our work included the design of the SBJ for the offshore wind farm Borkum Riffgrund I, 37 km off the German island of Borkum. The SBJ was designed with three cup foundations that are shipped into the subsea through section. It can be installed in a single lifting and assembly process, which reduces installation time and its associated costs. It also has a quieter installation, meeting the noise restrictions set to protect local ecosystems (image p. 19).

WORKING WITH WIND ENERGY SINCE 1986

With the rapid growth of wind energy production worldwide, Ramboll offers our clients international, multidisciplinary and wind specific competencies. We offer expert services for the different project phases from early feasibility, business case and impact assessment studies to planning, engineering, implementation, commissioning and the subsequent operation & maintenance and eventually life-time extension or decommissioning.

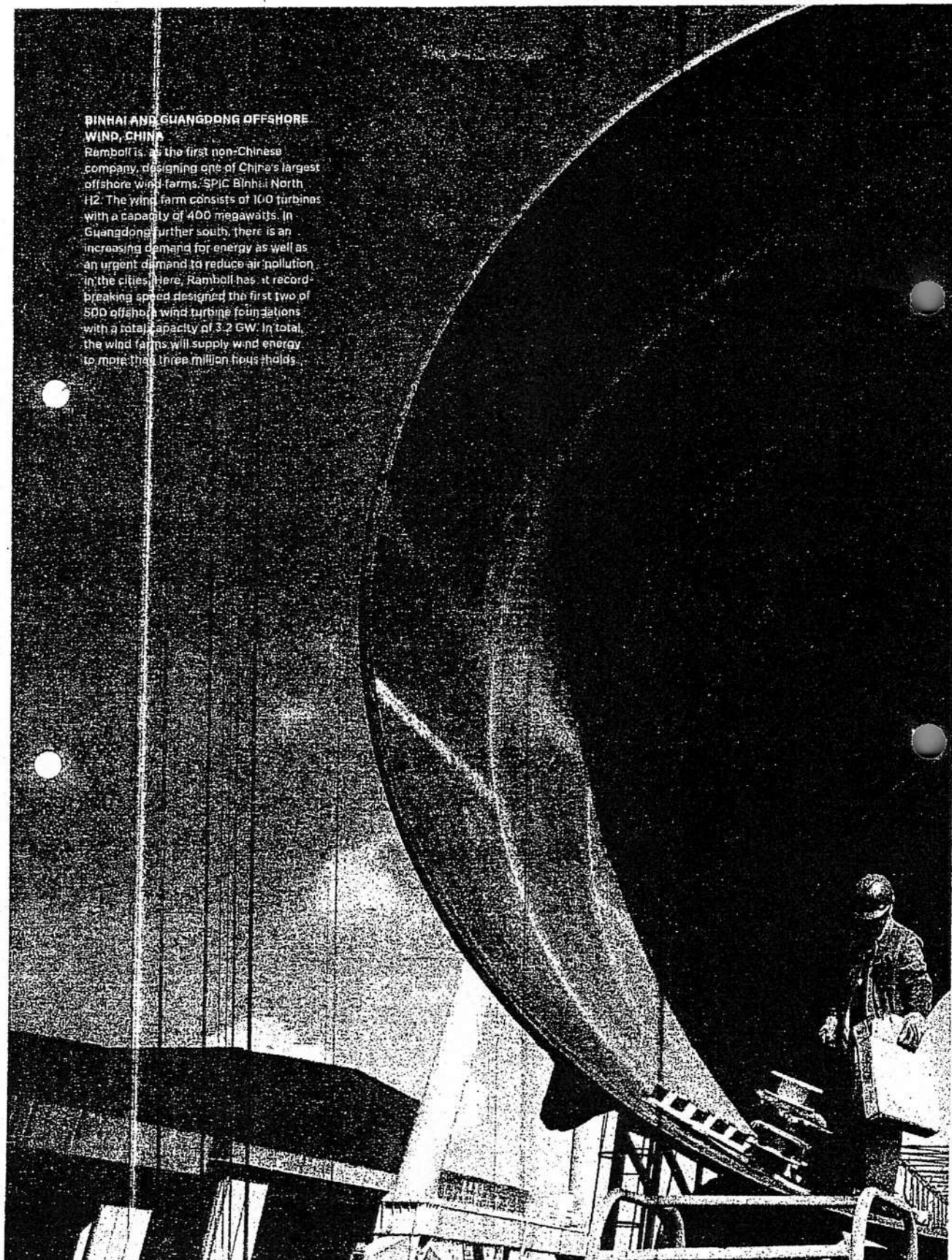
We can effectively manage the entire project or contribute with our expertise in different sub-projects according to our client's needs. Ramboll is a full-service consultancy and wind energy leader with global knowledge and a network of offices and resources that serve clients locally.



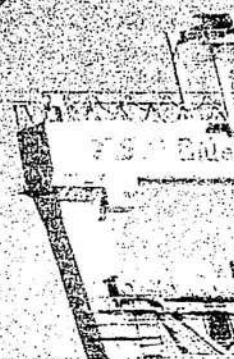
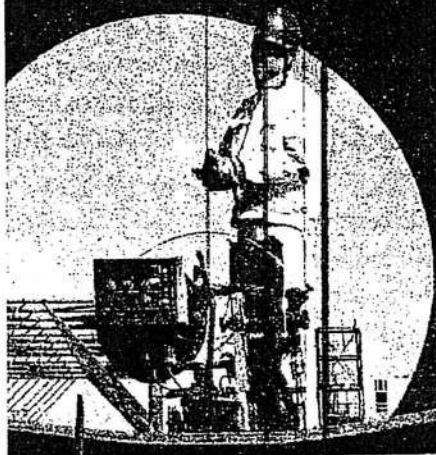


**BINHAI AND GUANGDONG OFFSHORE
WIND, CHINA**

Ramboll is, as the first non-Chinese company, designing one of China's largest offshore wind farms, SPIC Binhai North H2. The wind farm consists of 100 turbines with a capacity of 400 megawatts. In Guangdong further south, there is an increasing demand for energy as well as an urgent demand to reduce air pollution in the cities. Here, Ramboll has, at record-breaking speed designed the first two of 500 offshore wind turbine foundations with a total capacity of 3.2 GW. In total, the wind farms will supply wind energy to more than three million households.



• **MAKING CLEAN
WIND ENERGY
AVAILABLE
TO 3 MILLION
HOUSEHOLDS
IN CHINA**



SOLAR ENERGY

SOLAR HEATING

The best managed and optimised solar heating facility can utilise more than 45% of the annual solar radiation and convert this to district heating. Our experience includes consultancy services provided to both large-scale and small-scale solar heating plants, ranging from 200m² to more than 75,000 m².

SOLAR PV

Ramboll has over 15 years of experience working with solar energy. We have contributed to the success of more than 500 small to utility scale solar PV power projects, carried out in more than 25 countries around the world.

CAPITALISING ON THE LARGEST SOURCE OF ENERGY ON EARTH

With smart engineering at the core of our work, Ramboll is a world leading consultant and auditor, providing a full range of solar services. We assist our clients with comprehensive advice and future-proof solutions based on expert knowledge and state-of-the-art technology.

Solar PV

Our multidisciplinary structure enables us to offer holistic services covering every aspect of a solar PV project worldwide. Specialised teams are assembled from across the entire Ramboll group to ensure that the strongest expertise is applied to each individual project. Our services within solar PV range from expert planning, engineering and project management to resource and financial assessments, as well as other specialist studies including ESIA, grid impact studies, and performance monitoring.

As a one-stop-shop of energy services, we offer singular, modular and tailor-made solutions for individual project requirements throughout the entire project life. With our multidisciplinary approach

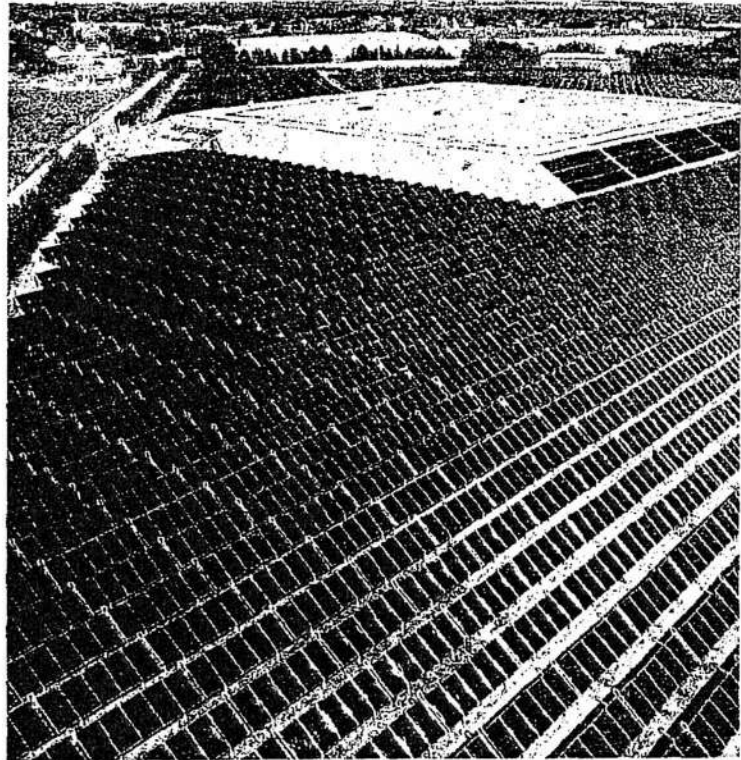
we provide innovative, efficient and cost-effective solutions for all kinds of solar PV projects, including solar PV power plants for IPPs and utilities, solar PV for commercial clients with self-consumption and solar PV as a substantial part of hybrid energy systems. For every project, we always strive for sustainability and with that in mind, we place the focus on designing long-lasting solutions.

Solar heating

Large-scale plants are a special Scandinavian concept for solar heating, supplying energy to the local district heating network through a heat accumulator. Ramboll has participated actively in the development of these solar heating plants and performed research into the latest technologies and underground storage systems. We also provide consultancy services relating to their integration into existing heating and combined heat and power plants.

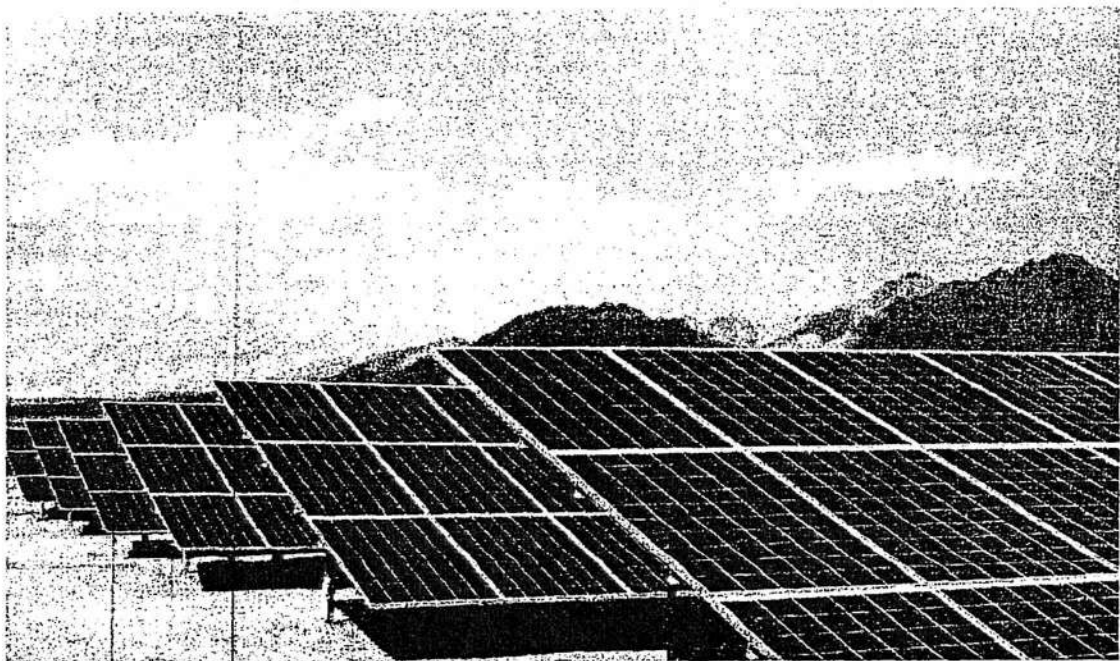
BOOSTING SOLAR HEATING IN DENMARK

In cooperation with Ramboll, three Danish municipalities in southern Jutland - Løgumkloster, Vejers and Gram - converted to new flexible district heating solutions. For Løgumkloster, Ramboll devised a strategic master plan for heat production that considered a series of heat production technologies, including different types of electric heat pumps, absorption heat pumps, solar heating and thermal storage of various sizes, biomass boilers, electric boilers as well as optimisation of existing gas. In Gram, Ramboll assisted our client in tripling the size of its solar heating facility.



SHAMSUNA SOLAR PV, JORDAN

Acting as the Owner's Engineer for the first utility scale (10 MW) solar PV plant in Jordan, Ramboll provided technical support throughout the whole project including feasibility, development, planning & design, EPC tendering process, construction supervision and commissioning.



WASTE-TO-ENERGY

EXPERIENCE

Ramboll has worked on waste-to-energy projects in 45 countries, providing consulting services for 155 new units and retrofits.

WASTE-TO-ENERGY FACILITY IN LONDON, UK

Ramboll is acting as Technical Advisor to North London Waste Authority (NLWA) in the delivery of its North London Heat & Power Project. Ramboll is leading the design development of a new state-of-the-art 700ktpa waste-to-energy facility with combined semi-dry/wet flue gas treatment to meet Best Environmental Practice. We have also conducted thorough technical assessments of the existing waste-to-energy facility to establish its condition and future expected performance, preparing recommendations for investment requirements and costs over short-term and medium-term horizons.

ICONIC AMAGER BAKKE, DENMARK

Amager Bakke is one of the most efficient waste-to-energy facilities in the world. As the Owner's Engineer, Ramboll has assisted in the planning and implementation of the 560,000 tpa facility, which produces 20% more energy per tonne of waste compared to the plant that it replaces and has emission levels far below limit values. The facility is fully integrated into the urban setting, surrounded by high-end flats, and features a ski slope and other recreational facilities on the roof (image p. 25).

LEADING WASTE-TO-ENERGY CONSULTANT

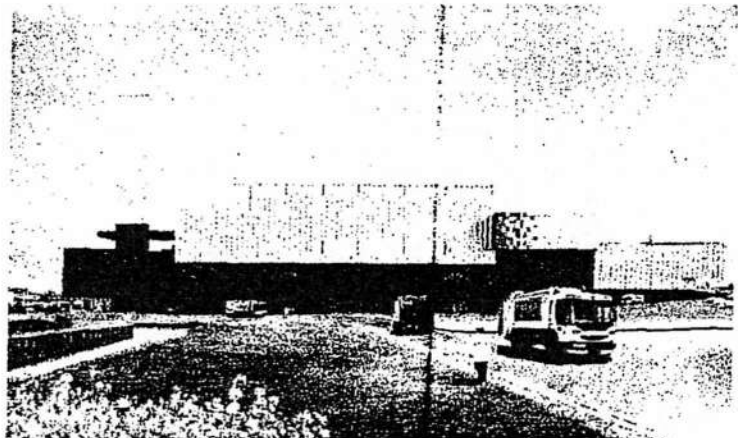
As the world population and energy consumption increase there is a pressing need for the reduction of waste generation, high-quality recycling and the use of residual waste for efficient and clean energy generation.

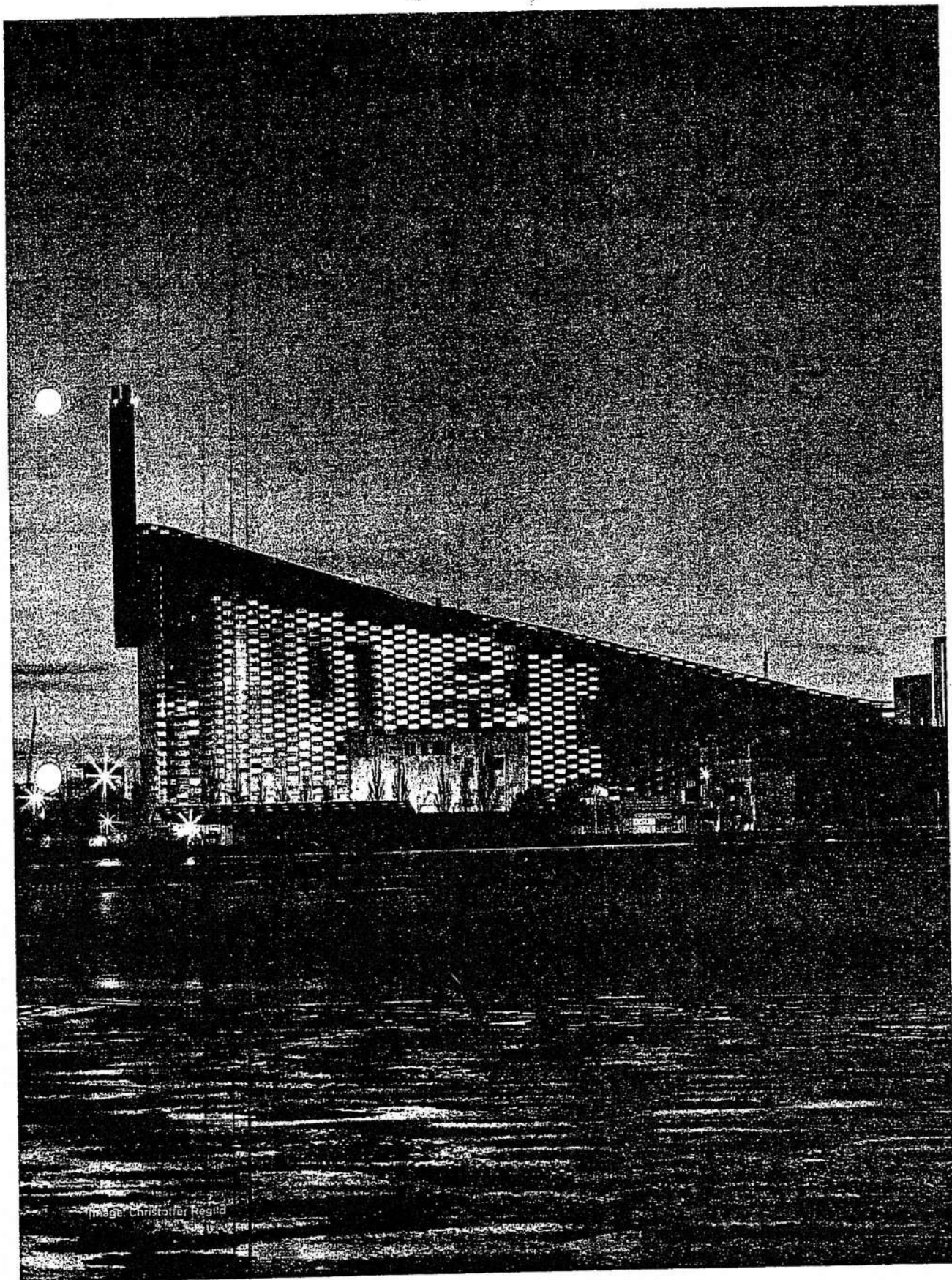
Recovering energy from waste
Ramboll is the world's leading waste-to-energy consultant with unmatched technical insight.

We have an extensive portfolio of successfully completed projects that involved the planning, engineering, procurement and contract management of waste management facilities. We assist our clients through all phases of the project - from idea to operation - and the combination of our experience and expertise means that we can provide no-learning-curve client support.

Our holistic specialist knowledge covers all aspects of asset management, including upgrades and retrofits, and always with a focus on cost and process optimisation.

Biogas from waste
Organic waste has become an important raw material for boosting biogas production from both manure and sewage sludge. Biogas can be used locally for the generation of electricity and heat or it can be upgraded for injection into the natural gas network or utilised as a transport fuel. Ramboll has many years of experience in the successful implementation of biogas projects. Our technical expertise enables us to handle the specific challenges that arise when using organic waste for the production of biogas.





POWER GENERATION

EXPERIENCE

Ramboll has designed and constructed more than 100 major power plants, including some of the most energy efficient plants in the world and has been instrumental in the ongoing conversion from fossil fuels to biomass.

TECHNICAL ADVISOR FOR POWER PLANT IN SALALAH, OMAN

Ramboll was selected by Oman Power and Water Procurement Company SAOC to be the technical advisor to the electricity off-taker of the Salalah II IPP Power Plant. The project resulted in a highly efficient plant with an energy conversion that went from 32% in the existing plant to 54% in the new plant. The new plant has a lower fuel consumption and reduced emissions.

LYNEMOUTH POWER PLANT CONVERSION TO BIOMASS, UK

Ramboll provided engineering consultancy services to the conversion of Lynemouth Power Plant from coal to biomass. The converted plant exports around 390MW of low-carbon electricity to the national grid. Wood pellets are imported to the plant from global fuel supply markets, via a newly constructed biomass import terminal at the Port of Tyne (Newcastle UK), which along with the power plant and site fuel storage and handling, also fell within the scope of Ramboll's work (image p. 27).

INCREASING ENERGY EFFICIENCY WHILE REDUCING CLIMATE IMPACTS

As the world shifts towards a sustainable energy mix, there is a need for thermal power generation plants to reduce emissions, by maximising efficiency or alternatively by switching to the use of renewable fuels such as biomass. Similarly, there is a need for plants to operate more flexibly as the level of intermittent energy sources increases.

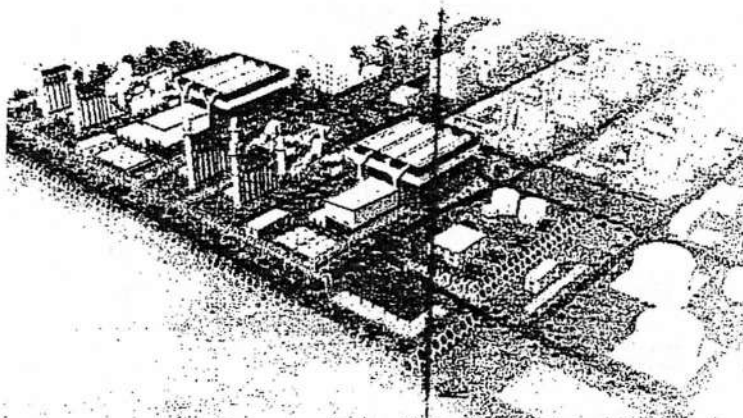
Ramboll has pioneered the development of innovative power plants worldwide, having particular expertise in high efficiency power plants, biomass and bioconversions, and cogeneration (CHP).

We have extensive experience in the design and implementation of flexible, fuel efficient combined cycle and major thermal power

plants, including expertise in supercritical and ultra-supercritical boiler plants.

Our unique position has been acquired through our contribution to the detailed development and implementation processes of some of the world's most efficient power plants.

Our specialist knowledge covers the full project life-cycle, from early feasibility study stages through to implementation and subsequent operations and maintenance support, failure investigation, and power plant rehabilitation and upgrades. Throughout all phases we always strive to set and achieve the highest standards of health and safety of a project and subsequent plant operation.



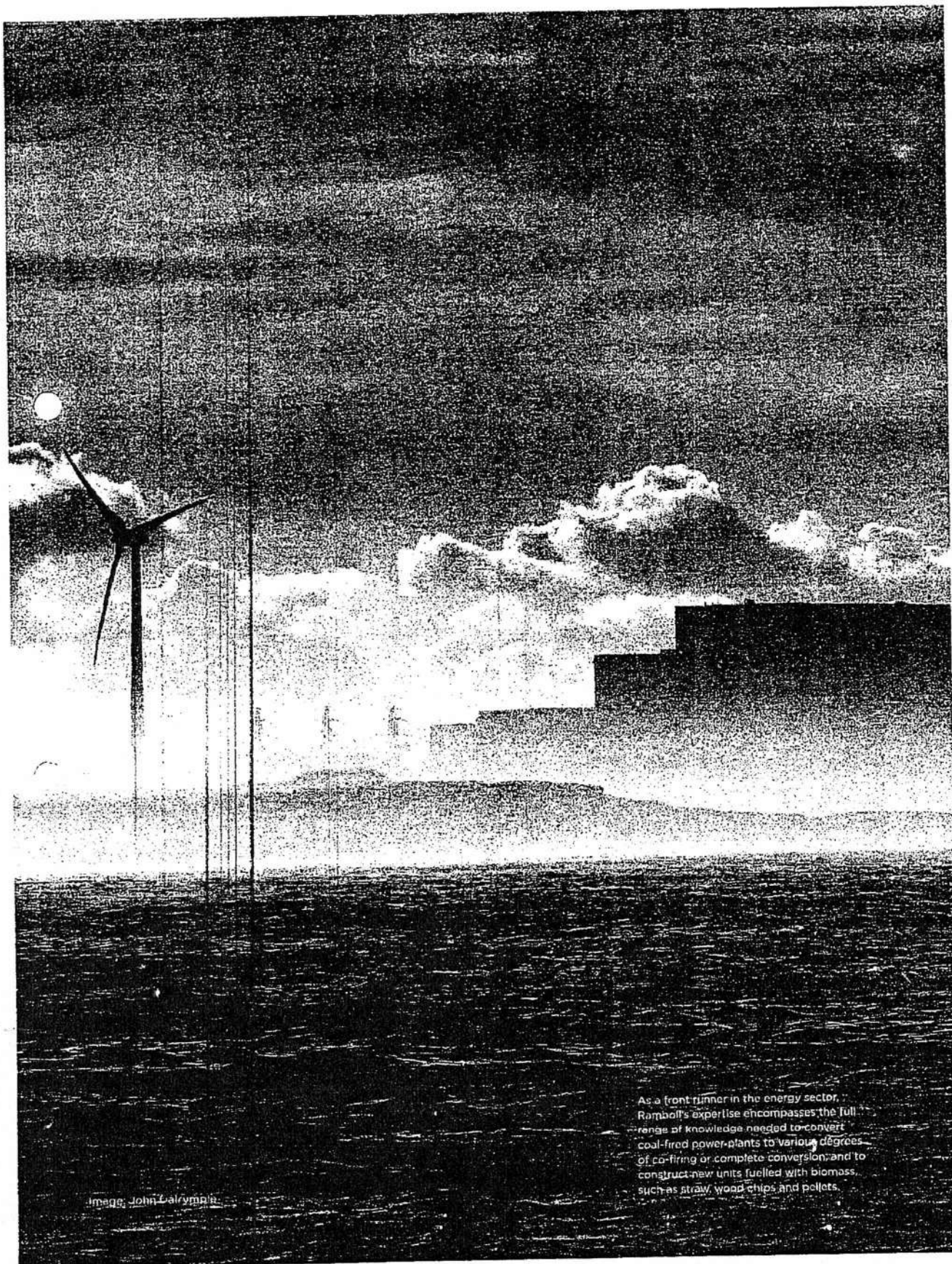


Image: John Calrymba

As a front runner in the energy sector, Ramboll's expertise encompasses the full range of knowledge needed to convert coal-fired power plants to various degrees of co-firing or complete conversion, and to construct new units fuelled with biomass, such as straw, wood chips and pellets.

OIL & GAS INSTALLATIONS

**RAMBOLL IS INTERNATIONALLY
KNOWN FOR OUR OPTIMISED OIL & GAS
DESIGN SOLUTIONS**

RECORD BREAKER

Ramboll broke the world record for deep water installation of a 36" pipeline.

As global energy consumption continues to grow, oil and gas will continue to play an important role in the world's energy mix for many years to come.

To make it in today's fast-paced and competitive oil and gas market, companies depend on advanced technical solutions that combine economic efficiency with stringent health, safety and environmental standards in the production and distribution processes. These elements form an integral part of Ramboll's independent and multidisciplinary consultancy service, which covers the entire asset life cycle - from early phase studies, FEED, detailed engineering,

modifications, maintenance and lifetime extension to decommissioning.

We excel in consultancy and have designed offshore structures for industry giants such as Total, ConocoPhillips, INEOS and Equinor since the 1970s.

Ramboll works across the oil and gas sector, covering engineering services within energy & infrastructure consulting, offshore production facilities, onshore production & refining, pipelines, and Gas & LNG.

REMARKABLE CULZEAN

The Culzean field was discovered in 2008 and is one of the largest fields in the British North Sea. With temperatures reaching 170 degrees C and the pressure being three times higher than average fields, a platform optimized for these conditions is paramount. Ramboll carried out the detailed design of three jackets for Maersk Oil (now Total).

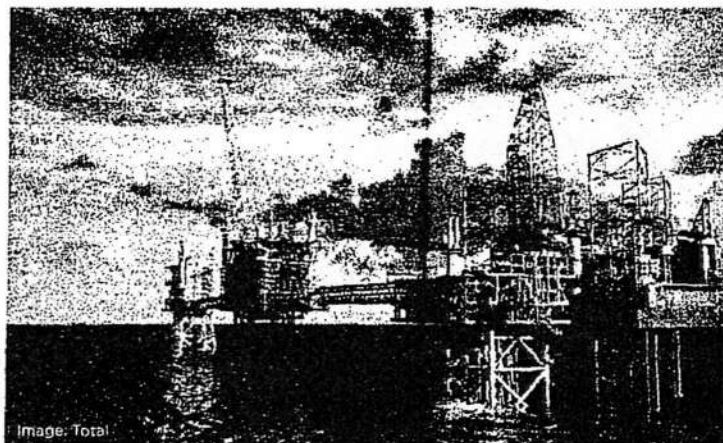
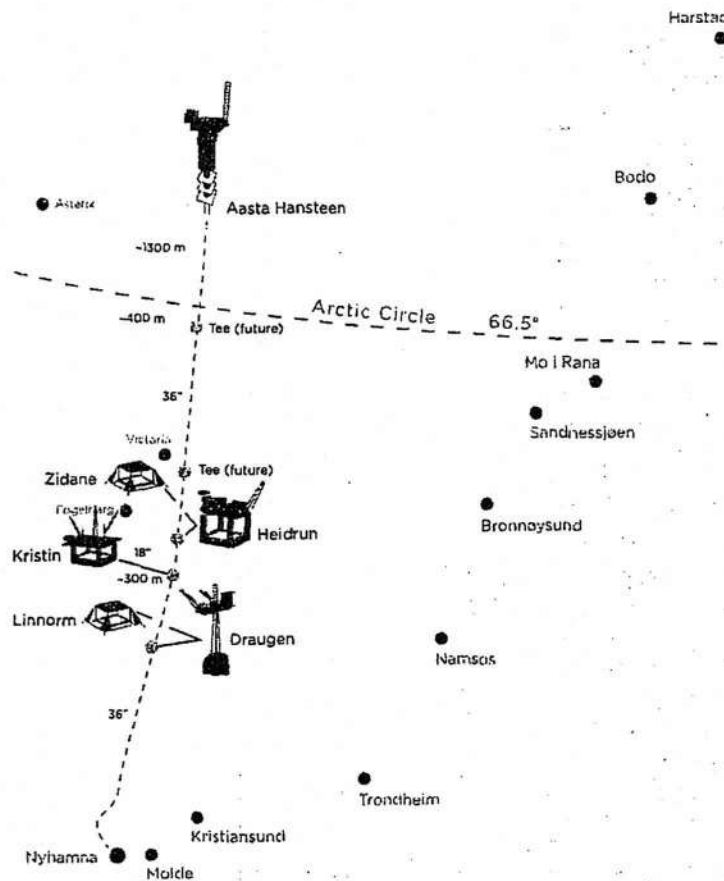


Image: Total

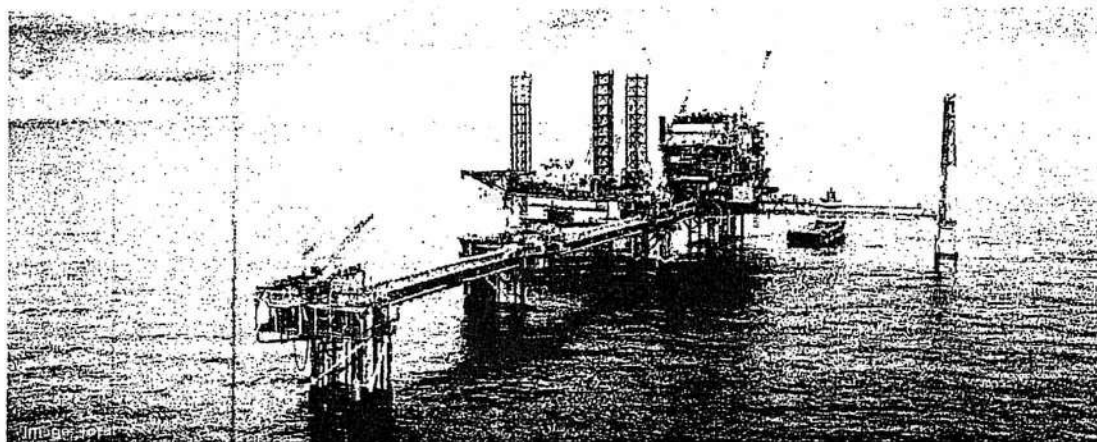


RECORD-BREAKING POLARLED PIPELINE

This unprecedented 482 km pipeline crossing the Arctic Circle on an extremely uneven seabed connects new fields in the Norwegian Sea with existing infrastructures to secure future energy supply in Europe. The pipeline was installed at water depths reaching 1,265 m, setting a world record for deep water installation of a 36" pipeline. Ramboll was instrumental in designing the pioneering technical solution for the pipeline, incl. FEED, detailed design, route optimisation, pipeline tie-in, geotechnical foundation design, risk and safety, EIA, and interface coordination.

INVESTIGATING TWO CONCEPTS FOR THE TYRA FIELD, NORTH SEA

The Tyra Field in the North Sea has been in production for thirty years, and the facilities are suffering from seabed subsidence, old age and increasing operating expense. Maersk Oil (now Total) was assessing several lifetime extension options to make continued operation feasible. For the Tyra Future redevelopment project, TFU, Ramboll carried out two pre-FEED (conceptual) studies. Concept 1 focused on examining the rebuild of Tyra East into an unmanned satellite producer, while concept 2 investigated an option to rebuild Tyra East as a field centre with new topsides for several of the existing wellhead and riser platforms.



GAS & LNG

GLOBAL FOOTPRINT

Ramboll's gas & LNG portfolio includes a worldwide geographical footprint, from Europe to Morocco, Uganda, Iraq, Qatar, Yemen and Venezuela.

BRIDGING THE GREEN TRANSITION

With modern society relying heavily on energy for its continuance and development, governments and energy companies alike are concerned with finding the right energy mix that will meet the demand while allowing the integration of renewable energy. As a future-driven consultancy, our expertise within energy and renewables can successfully be applied to gas projects, bridging the transition to cleaner energy forms.

Gas forms a substantial part of the energy mix that keeps modern society running today, and will continue to do so in the future.

With origins in a gas-producing country, Ramboll perfectly understands energy providers' challenges and opportunities. Our holistic approach to gas & LNG solutions considers the socioeconomic, the environmental and the public and political factors that influence the market in order to provide the most profitable and efficient energy solutions in all the projects we are involved in.



Ramboll has provided the gas sector with multidisciplinary engineering solutions for the past four decades. Our expert know-how and unique experience range from onshore and offshore gas production to infrastructure projects.

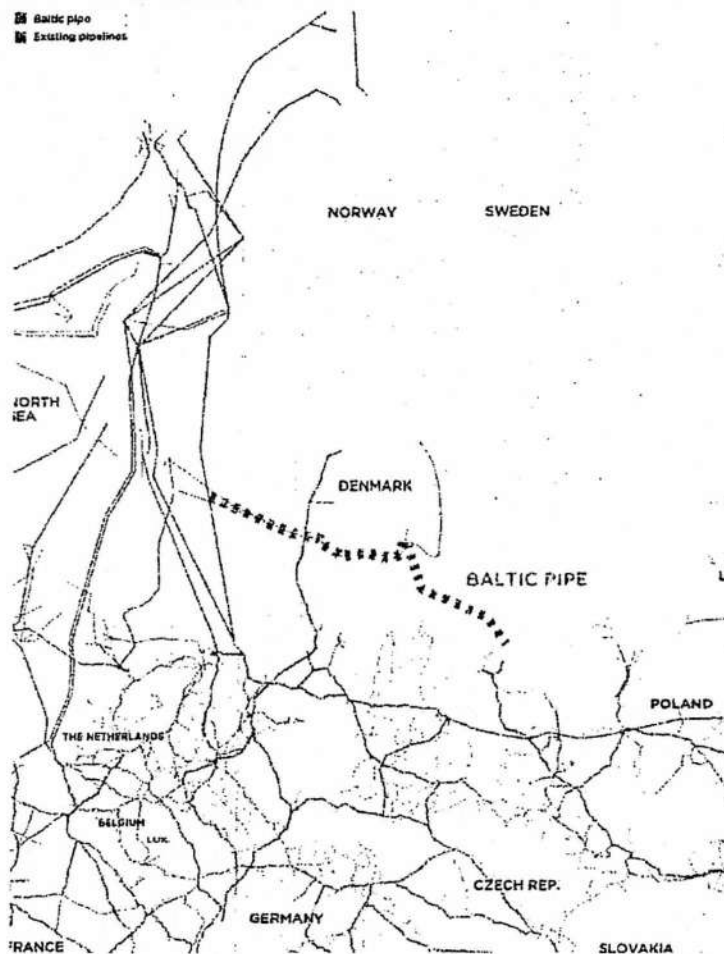
TECHNICAL ADVISOR FOR GAS-TO-POWER PROJECT, MOROCCO

Ramboll was selected by Morocco's state power and water utility ONEE to act as the technical advisor to a gas-to-power project, in a joint venture with French partner Sofregaz. The gas-to-power project is part of a programme by ONEE to add 6 GW of flexible, largely gas-fired, power generation capacity, 4 GW of interconnectors with neighbouring countries, and 2 GW of pumped hydro, all by 2030. The planned LNG infrastructure and gas-fired power plants will enable Morocco to manage intermittency as it expands renewable capacity to over half of the installed mix in 2030.





 Baltic pipe
 Existing pipelines



DEVELOPING A GAS SECTOR MASTERPLAN FOR BANGLADESH

Ramboll was awarded the World Bank sponsored project for the development of the Bangladesh Gas Sector Master Plan, aimed at providing Bangladeshi authorities and state companies with a strategic and technical plan for the long-term development of the gas sector in the country.

TECHNICAL ADVISOR FOR THE BALTIC PIPE

Since finalising a feasibility study in 2016 and the EPII terminal feasibility study in 2017, Ramboll has been the technical advisor for the Baltic Pipe project. The Baltic Pipe is recognised as one of EU's projects of common interest (PCI) and aims to further strengthen the European internal energy market. The Baltic Pipe will provide affordable, secure and sustainable reliable energy not only in Denmark, Poland and Sweden, but also in Central and Eastern European countries and Baltic countries.

DISTRICT ENERGY

EXPERIENCE

Based on 40 years of experience, Ramboll has provided consultancy services to more than 200 district heating systems worldwide ranging from small village schemes to city-wide transmission networks.

DELIVERING OPTIMAL SOLUTIONS FOR DISTRICT HEATING AND COOLING SYSTEMS

District energy systems have several benefits including improved energy efficiency, enhanced environmental protection, ease of operation and maintenance, as well as reliability, comfort and superior convenience for consumers.

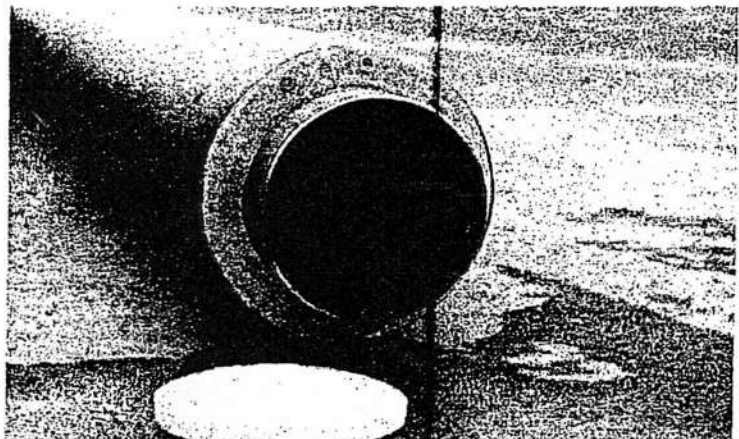
With our decades of experience, Ramboll is globally regarded as one of the most experienced district energy consultants in the world. We are also one of the very few consultants that offer our clients a full range of services on district energy projects from feasibility studies and planning to follow-up on operation and maintenance.

Based on our interdisciplinary approach, our district energy, waste-to-energy, CHP, renewable energy and building installation teams work closely together to provide optimal use of heating and cooling sources.

We use our expertise to offer our clients more sustainable solutions based on the most advanced renewable technologies including biomass plants, geothermal and solar thermal. By use of large heat pumps - which enable the co-production of heating and cooling by reusing surplus heat from facilities like data centres - we also work with electricity integration in the district energy systems.

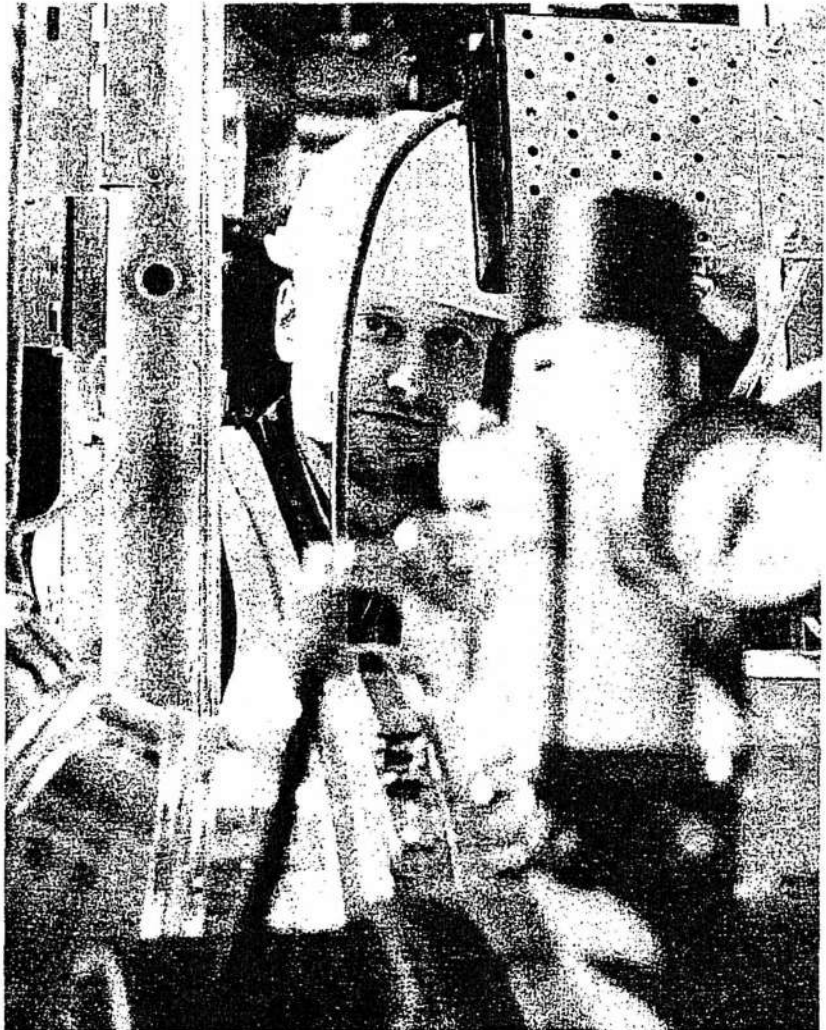
COPENHAGEN DISTRICT HEATING SYSTEM, DENMARK

Copenhagen's district heating system is one of the largest in the world, and the associated networks supply low-carbon heat to a city of one million people. For more than 50 years, Ramboll has been the Metropolitan Copenhagen Heating Transmission Company's main consultant, providing consultancy assistance during all stages of the project from planning and design to operation and maintenance of the city-wide system.



REPLACEMENT OF DISTRICT ENERGY SYSTEM AT STONY BROOK UNIVERSITY, US

The new district energy system supports all the thermal needs of Stony Brook University, which is the largest research University in the State University of New York system. The work was performed on an active university campus and phased to minimise interruptions of academic work, and to avoid the use of temporary systems.



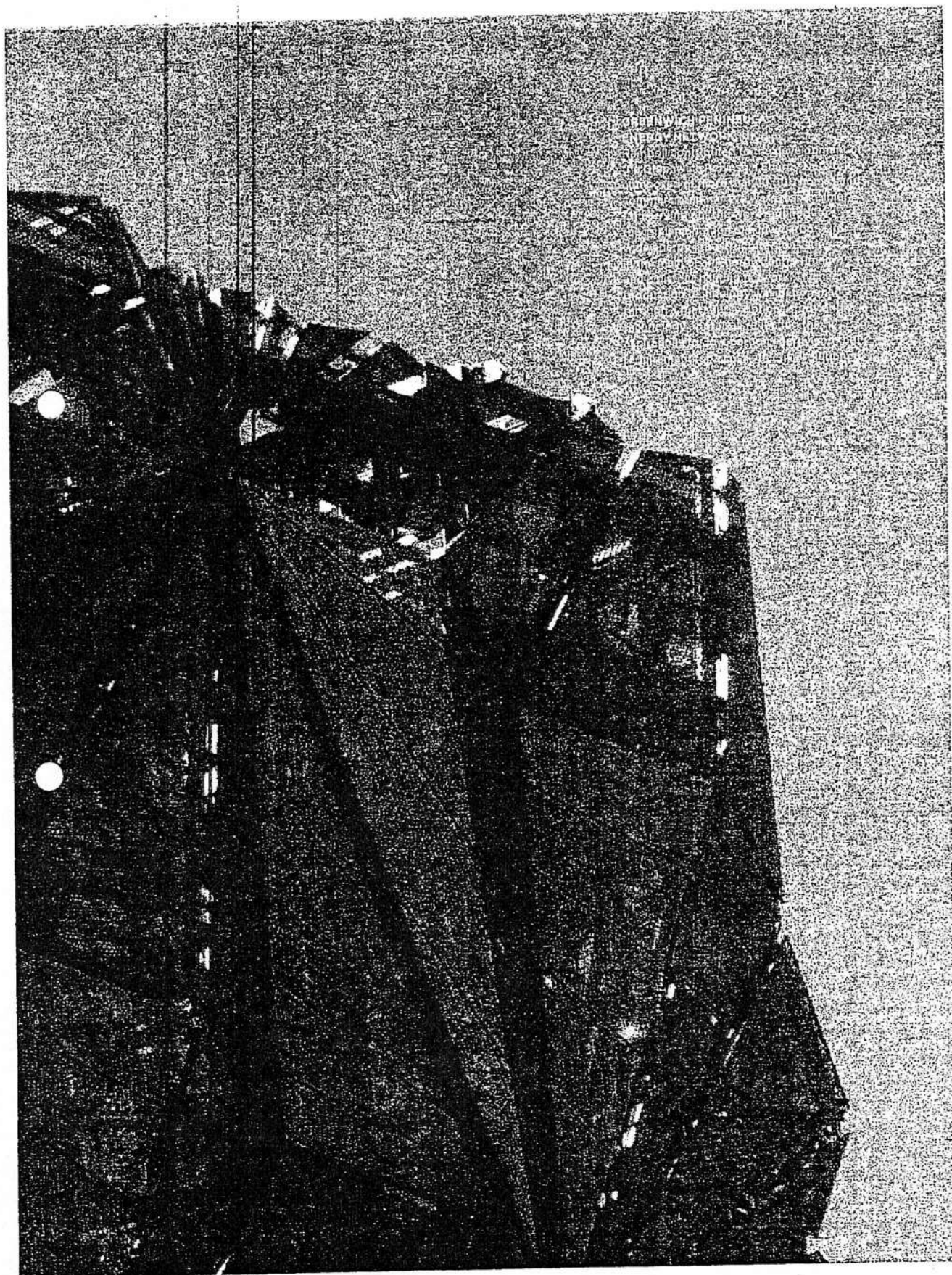
DATA CENTRE SURPLUS HEAT RECOVERY, DENMARK

Rambol has provided consultancy services for the district heating company Fjernvarme Fyn on an energy centre with large heat pumps, utilising excess heat from the servers of a Insga data centre in Odense. The heat pumps increase the temperature of the waste heat, so that it can be used in the local district heating network. It will be Denmark's largest heat pump to date, and utilisation of data centre excess heat has not been done in this scale before anywhere in the world.





• HELPING
CITIES
FLOURISH
WITH
• COST-EFFICIENT
DISTRICT
HEATING
SOLUTIONS



POWER TRANSMISSION AND DISTRIBUTION

PEOPLE

Ramboll has 120 specialists in power transmission and distribution providing services that range from specialized technical advice to full engineering design solutions and project management.

UPGRADE OF POWER TRANSMISSION SYSTEM IN NORWAY, STATNETT

Due to the age and technical condition of existing power lines, the electricity demand growth in cities and the push for integration of renewables, the transmission grid capacity in Norway needed reinforcement. Ramboll acted as the project manager for this reinforcement, including a new 420kV transmission line and the upgrading of existing lines. This has made it possible to connect new wind power to the main grid and provide a secure supply of energy in Central Norway (image p. 34 bottom left).

ELECTRIC DISTRIBUTION UPGRADES AT ITHACA COLLEGE, NY, USA

Over the past 25 years, O&G, now Ramboll, has performed electrical studies, design and construction administration for new and upgraded medium voltage electrical distribution projects throughout the campus of Ithaca College. The purpose of these projects was to provide power reliability to 56 buildings on campus, working closely with the campus administration to minimise disruption of daily operations (image p. 37 bottom right).

ENABLING THE INTEGRATION OF RENEWABLE ENERGY INTO THE ELECTRICITY GRID

In a world where energy and power demands are rapidly changing, and where the power generation mix is moving from thermal to renewable sources, Ramboll's holistic approach enables us to identify the changing demands on the power transmission and distribution networks, while our in-depth knowledge of such networks enables us to provide effective long-term solutions for the networks of the future. The power networks of the future will need to provide security and reliability with changing generation profiles and higher levels of intermittency. With its knowledge and expertise Ramboll is well placed to advise clients on the impact of new generation connections and the needs of future networks.

We tailor our services to meet our clients' needs. Our services range from specialised technical advice and power system studies (steady state and transient studies) to techno-economic feasibility studies, technical due diligence, front end engineering design and project management. We offer

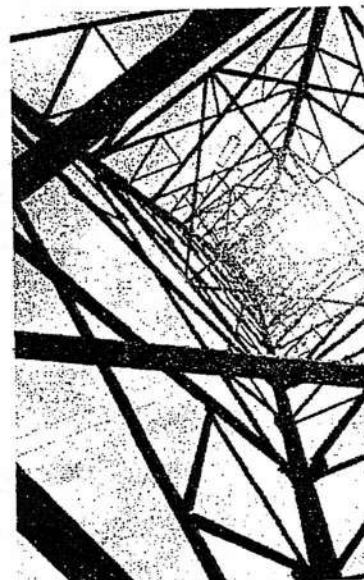
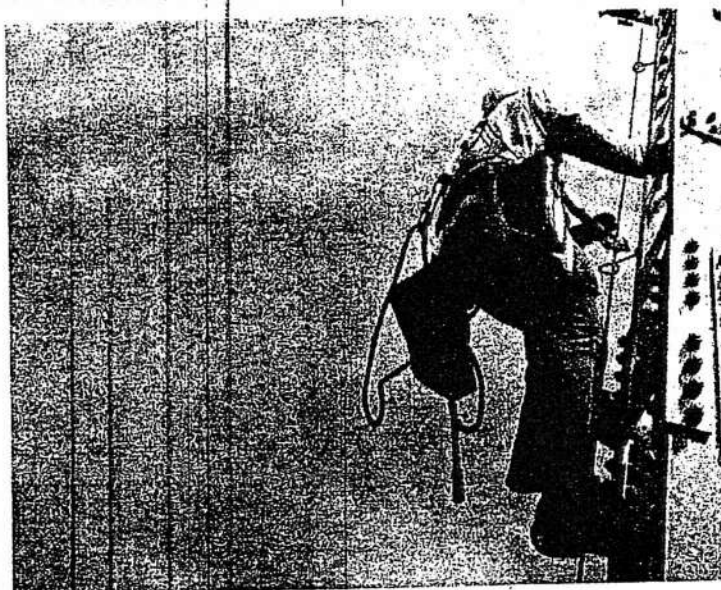
full Owner's Engineer services for project delivery as well as detailed engineering design when appropriate.

We have a wealth of expertise and experience in power system studies, grid connections for thermal and renewable generation and large industrial loads, offshore transmission systems, transmission lines and towers, cables, AIS and GIS substations, switchgear, transformers and reactors, protection, control and automation and HVDC interconnections. Our capability is at voltages up to and including 500kV.

Our power transmission and distribution skills are complemented by Ramboll's expertise in thermal and renewable power generation, offshore substation platform design, civil and structural engineering and environmental impact studies.



TECHNICAL DUE DILIGENCE FOR OFFSHORE TRANSMISSION (OFTO) ACQUISITION, UK
Rainbolt provided technical due diligence services to Diamond Transmission Corporation (part of the Mitsubishi Group) in connection with the acquisition process for the UK offshore transmission (OFTO) schemes. These schemes provide the transmission link between the offshore wind farms and the onshore grid system.



TOWERS

RANKING

Ramboll is ranked the no. 1 design company globally by ENR within Towers & Antennae.

FOOTPRINT

More than 130,000 masts and towers around the world bear the Ramboll stamp.

AN INNOVATIVE SOLUTION FOR OVERHEAD TRANSMISSION LINE TOWERS TO ENERGINET

Together with the architect Dissing+Weitling, Ramboll was appointed to design the innovative Thor towers for the 2x400 kV grid for Energinet. The transmission line will establish high voltage connection in the southern and western part of Jutland, Denmark. Compared to traditional transmission line towers made of steel angle bars, the new tower is made of steel tube elements to obtain an elegant design, which is installed and maintained with less effort, compared to existing power pylons.

150M MAST FOR LUND UNIVERSITY, SWEDEN

Ramboll entered into a full turnkey contract with Lund's University for the engineering, procurement and construction (EPC) of a 150m guyed mast-mast. After completion of the detailed design, Ramboll handled the manufacturing and delivery of mast and accessories before completing the installation of mast and foundations. Installation of the mast sections was performed by helicopter (image p. 39).

COST-EFFICIENT DESIGN PHILOSOPHY

Ramboll has been working with towers since the company was founded in 1945. We offer our clients a broad spectrum of consultancy services from analysis, technical due diligence, measurement and design to construction of masts and towers.

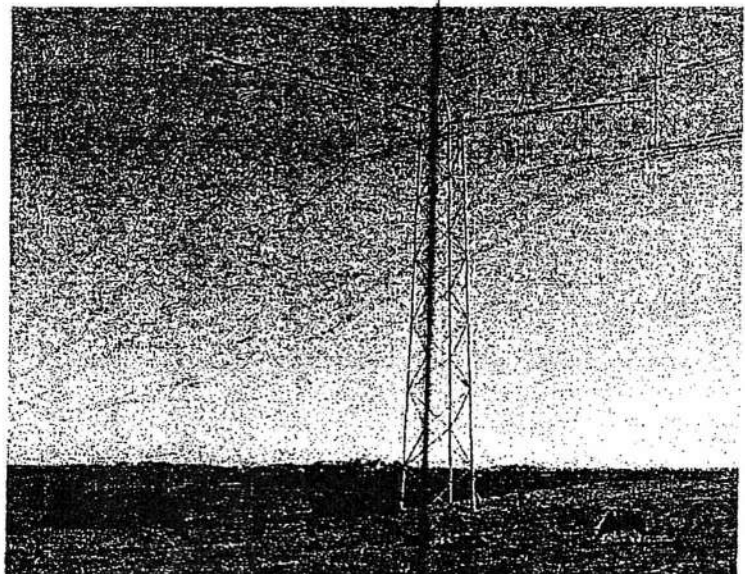
Ramboll focuses on reducing the total site costs for our clients, without compromising on sustainability and high quality. Our global presence and extensive engagement in international standardisation and R&D ensures

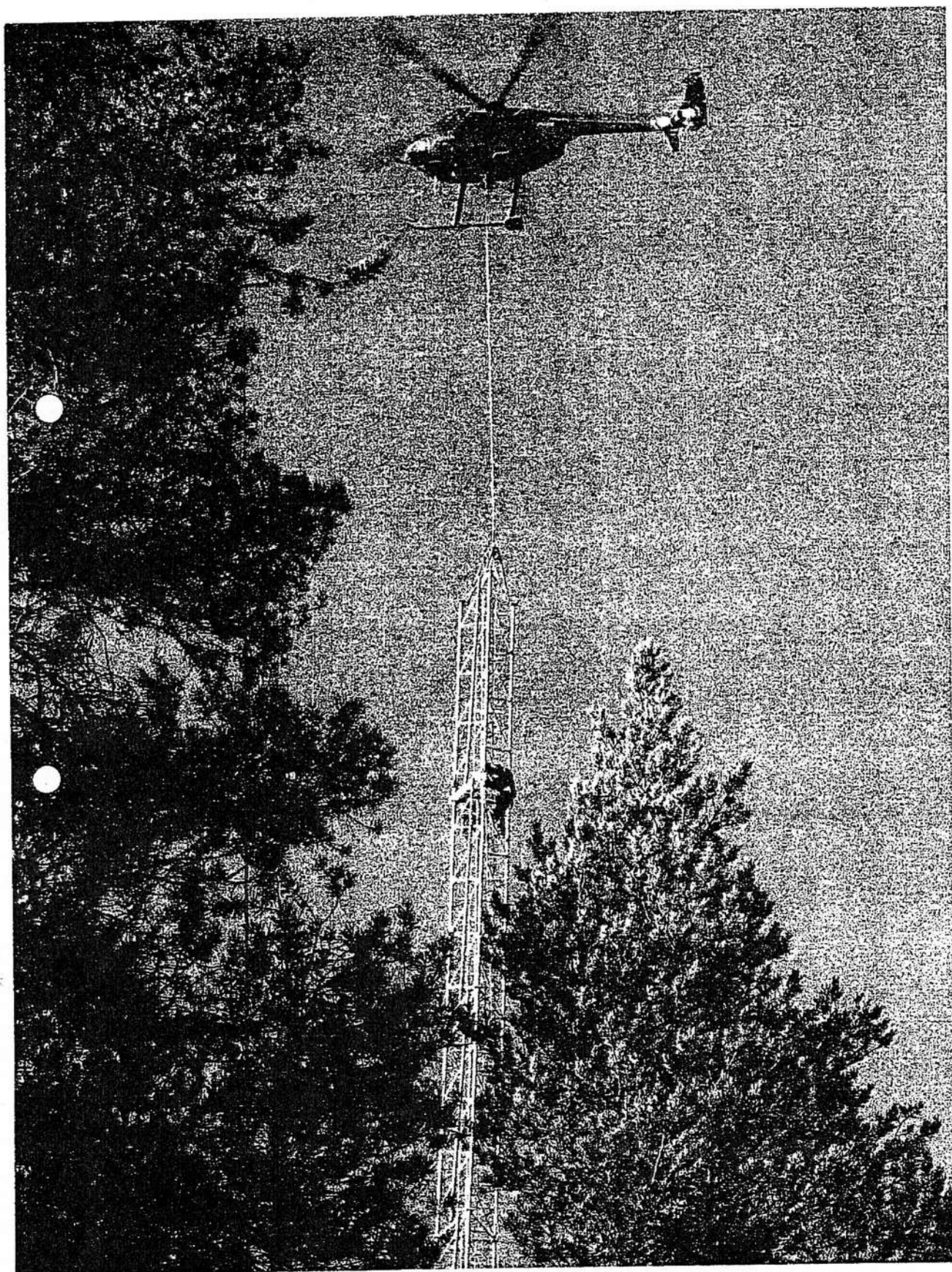
that we can continue to provide world class solutions to our clients.

Based on our cost-efficient philosophy, our masts and towers are optimised by minimising wind load, foundations, logistics and installation time.

Supply and installation

In selected business segments Ramboll offers a full turn-key towers solution to our clients, from engineering, and procurement to construction (EPC).





ENERGY STORAGE

WORLD RECORD BREAKER

Ramboll broke the world record for largest heat storage pit with the design and construction of a 200,000m³ heat storage facility.

USING SURPLUS ENERGY

The challenge for energy storage facilities is not only to increase the market share of surplus energy from wind, solar and hydro, but rather to use it cost-effectively.

KEY TO LOW-CARBON COMMUNITIES

Ramboll offers our clients the smartest solutions for their projects and society based on expertise in analysing the energy infrastructure and its energy carriers for electricity, gas and thermal energy. We take into account quality and time – ranging from seasonal storage to frequency stabilisation. Our solutions cover electricity, gas, district heating (hot water) and district cooling (cold water), and encompass a wide range of storage solutions including heat storage tanks and pits, cold storage tanks, natural gas storage, compressed air in caverns, electric batteries, frequency stabilisation, hydro power and pump stores, and steam storage tanks.

Cities acting as a virtual battery

A smart energy system that relies on fluctuating energy sources such as wind and solar power requires new, flexible energy usage and storage solutions. The water-based integrated energy system in the cities can be exploited as a cost-effective means of using and storing electricity.

With its large thermal storage facilities for hot and cold water in combination with large heat pumps, compressor chillers and electric boilers, the system can use a lot of electricity while the prices are low and avoid electricity consumption in times of high prices. Compared to individual solutions without

storage capacity, i.e. small heat pumps and compressor units that need electricity every day or even every hour, the water-based energy system is equivalent to a virtual battery.

Ramboll has been involved in a wide range of projects for planning and designing all components of the integrated energy system in cities, e.g. the district heating system in Greater Copenhagen.

Electrical storage

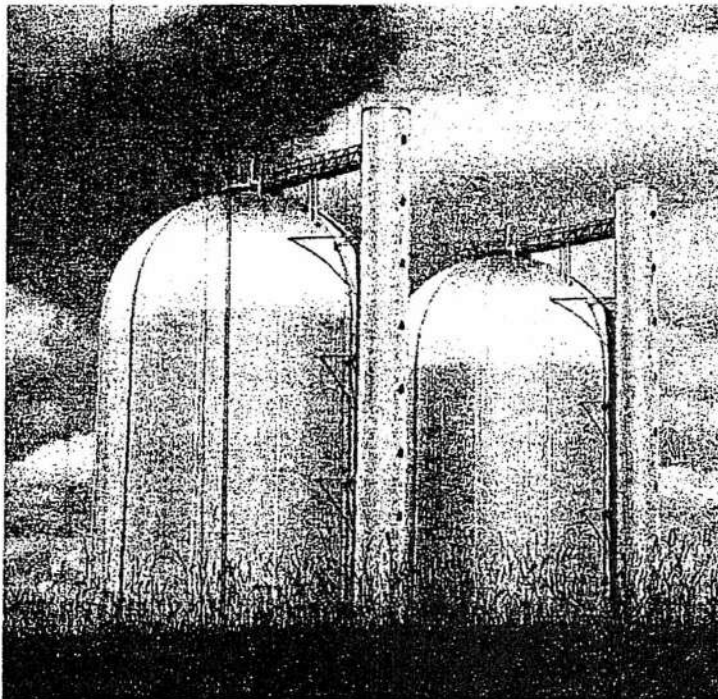
As emerging technologies, chemistries, and platforms (mobile, EV & stationary) mature, the future for electrical storage is very promising. These assets allow for great potential to dynamically act as a load or a resource, balancing in real time the many requirements of our critical infrastructure.

With our simulation tools, we support and design all kinds of battery storage and assist our clients in the implementation phase. Our services include both the electrotechnical design and the economic optimisation of the capacity and power. Depending on the application, battery storage today has several different functions and business models. They enable peak shaving, equalise the fluctuating feed-in of electricity from renewable energy plants and save the energy in times with excess renewable generation.



HEAT STORAGE PIT RECORD IN VOJENS, DENMARK

As a consultant for Vojens District Heating in Jutland, Denmark, Ramboll designed and constructed a 200,000 m³ heat storage facility in an old gravel pit. It was driven by an extension of the existing solar heating plant from 17,500 m² to 70,000 m² - breaking the world record in the process. The entire project was carried out without subsidy and has reduced the cost of heat production substantially.



CHP ACCUMULATOR TANKS, AVEDØRE PLANT, DENMARK

Ramboll designed large-scale heat accumulators, allowing the Avedøre CHP plant - one of the world's most efficient multi-fuel power plants - to decouple heat and power production, optimise demand economics and support a system with high wind power generation.

DIGITAL INNOVATION

DRIVING INNOVATIVE THINKING THROUGH SMART ENGINEERING

Innovation is at the heart of Ramboll's approach. We see creative thinking and innovation as key drivers for success and with that in mind, we continuously invest in the development of new engineering methods and techniques that harvest the full potential of new and existing technologies to create and offer more efficient and cost-effective services to our clients. Below are some examples of how we use the latest technologies to help our clients solve their problems and advance their projects.

True Digital Twin

Offshore structures such as platforms and wind turbines are billion dollar investments. With the True Digital Twin technology the operation and maintenance costs can be reduced and decisions on lifetime extension can be made on the basis of a genuine understanding of the structures.

Ramboll's True Digital Twin continuously monitors the structure in a digital model updated with real-time information about the loads affecting the structure, using an innovative structural health monitoring system combined with digitalisation. This intelligent asset management technology can be used for assets in other parts of the energy sector where structural behaviour can be monitored.

ROSAP/cloud computing

The Ramboll Offshore Structural Analysis Program - ROSAP - has been developed over the past 30+ years to meet the ever-increasing demands for structural design, optimisation and lifetime extension of offshore structures. ROSAP provides indispensable tools for new design, modification work and lifetime extension assessments of onshore and offshore steel structures, covering all phases from transport and lifting to in-service.

To further optimise the design, Ramboll has worked with several cloud vendors to improve its in-house software in this area through cloud computing, providing our engineers with a platform with faster, more robust and cloud-based storage and execution.

VR/AR visualisation

As our energy projects and designs become increasingly more complex, new solutions are required to visualise our projects, both in the design phase and during operation. Virtual Reality (VR) presents itself as a powerful technology that delivers more realistic and interactive visualisations of our engineering designs and models, while simultaneously enhancing the communication process with project stakeholders. Unlike VR, which requires an entirely virtual

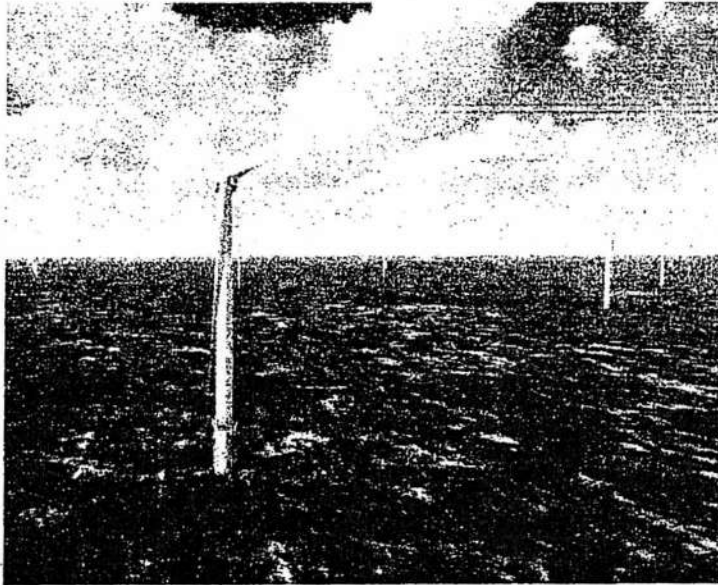
environment, Augmented Reality (AR) simply adds computer-generated images to the existing natural environment to enhance the current perception of reality. This is a strong project planning and implementation tool.

3D laser scanning and survey

Ramboll has worked with 3D laser scanning and surveying since the late 1990s. 3D laser technology facilitates the capture of physical objects such as structures, pipe work and mechanical components. Through survey analysis this is converted to a virtual but true to life as-built 3D model. With the 3D laser technology, errors can be prevented and new designs can be precisely tailored to fit existing layouts.

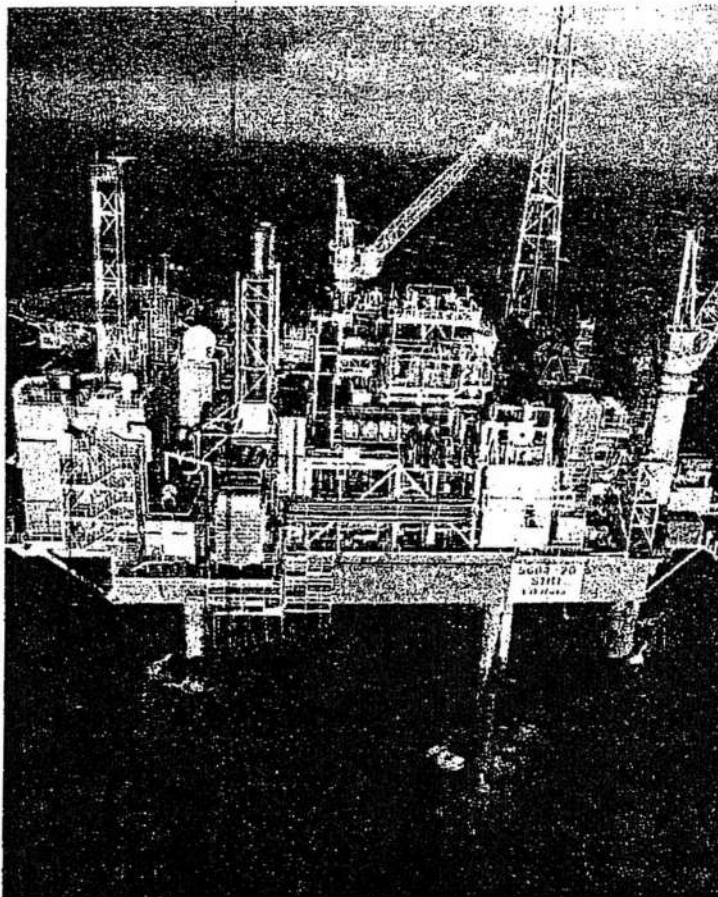
INVALUABLE SOFTWARE

Ramboll Offshore Structural Analysis Program (ROSAP) has been used for more than 3,300 individual foundation designs for wind turbines for 62 offshore wind farms around the world, accounting for a total tonnage capacity of 13,800 MW.



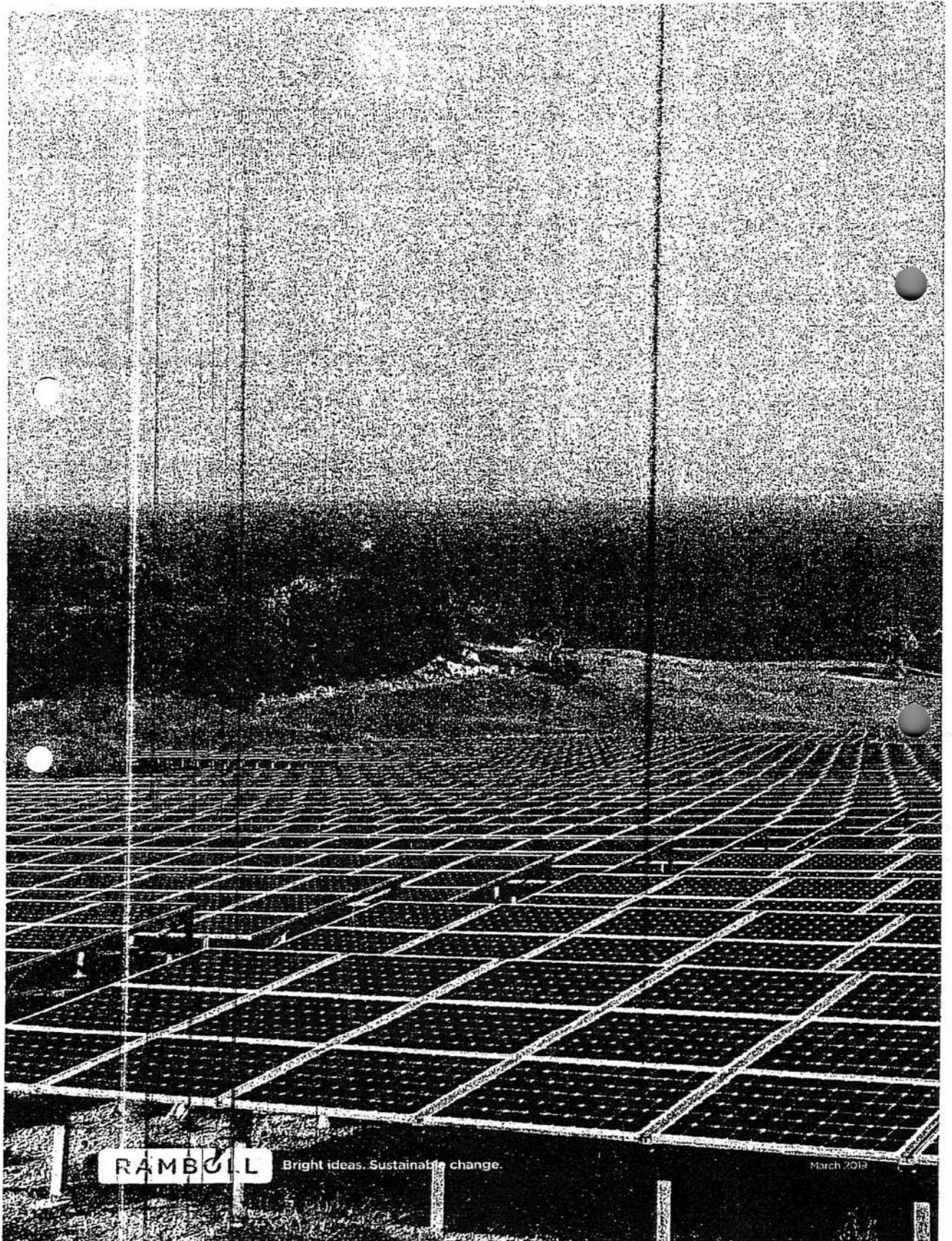
MONO BUCKET CONCEPT FOR OFFSHORE WIND TURBINE FOUNDATIONS

Ramboll has established a close collaboration with Universal Foundation on an on-going joint development project concerning the design and certification of the Mono Bucket concept, including load iterations with MHI Vestas Offshore Wind. We assisted our client with the design basis, design briefs, collision analysis, load calculations and structural verifications of the structures. The designs were subsequently turned into real-scale 3D models able to be visualised and interacted with using VR technology.



SIRI A TRUE DIGITAL TWIN (SHMS), NORTH SEA

For the Siri Offshore Platform located in the North Sea, cracks were observed in the structure. This required extensive repair and reinforcement, and analysis and re-certification for keeping the facility in production. Ramboll assisted the client by creating a True Digital Twin of the platform based on real-life measurement data from an installed Structural Health Monitoring System (SHMS). The purpose of the True Digital Twin was to improve and control the structural safety of the platform during all phases of the project from the time of observation of the crack development, during the re-assessment analysis and to final repair of the platform. The project resulted in the minimisation of costly shut-downs and platform evacuations, while maintaining a high safety level.



RAMBOLL

Bright ideas. Sustainable change.

March 2019

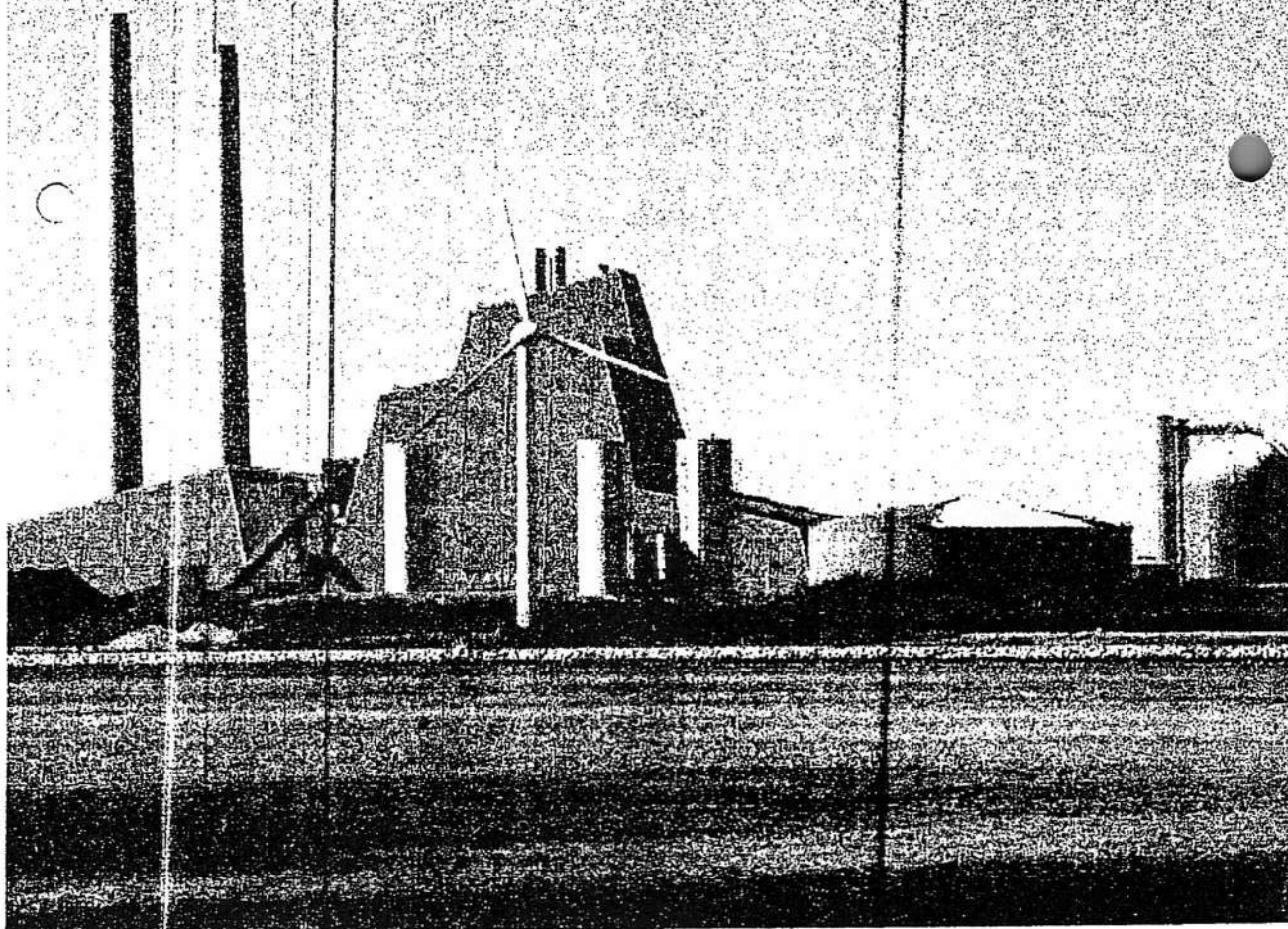
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Ramboll

RAMBOLL

POWERING THE FUTURE

CONSULTANCY ON FLEXIBLE, EFFICIENT AND RELIABLE
THERMAL POWER PLANTS



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RAMBOLL ENERGY

Ramboll has more than 45 years of experience in the planning, design and implementation of energy solutions.

Our energy team provides expertise on the full spectrum of technologies and all parts of the value chain from production through to transmission and distribution.

Our special competencies lie within thermal power, wind energy, waste-to-energy and district energy. Within these four areas, we provide a one-stop shop of services based on know-how and experience gained from a large number of projects, unmatched by other consultancies.

WHAT WE CAN DO FOR YOU

Modern energy systems face increasingly complex challenges. Global power demand is rising as societies develop, whilst we must also reduce climate change impacts. Growth in wind, solar and other renewable generation, along with the development of higher efficiency and flexible fossil fuel plants are increasingly seen as the key to delivering these reliable lower carbon solutions.

Sustainable solutions

The projects that we carry out for our clients typically provide the overall societal benefits of securing the supply of energy, reducing climate

impact, improving energy efficiency and countering resource scarcity.

We assist our clients in all project phases, ranging from planning and engineering design, to long-term operation and maintenance.

Special energy competency areas

Besides thermal power, we offer world leading competencies within offshore wind, waste-to-energy and district energy.

More than 65% of the world's offshore wind turbines rise from foundations engineered by Ramboll, and we have provided expert services to onshore wind farms with a nominal output of +60,000 MW in more than 60 countries.

We have worked on waste-to-energy projects in 45 countries, providing consulting services for 145 new units and retrofits.

We have provided consulting services to more than 200 district heating and cooling systems worldwide, ranging from small village schemes to city-wide transmission networks.

Thermal power services

Ramboll offers a 'one-stop shop' of services based on a multidisciplinary approach to power generation.

Our unique strength stems from the acquisition in 2011 of DONG Energy's in-house thermal engineering team, responsible for the project development and implementation stages of world leading high efficiency power plant projects right through to operations and maintenance support, failure investigation and power plant rehabilitation and upgrades.

Unlike many other consultants we are able to bring expert plant operational insight into new power project developments. Our power group has continued to strengthen with strategic recruitment of staff with extensive international power generation engineering consulting experience.

Thermal power experience

On behalf of our clients, we have designed and constructed more than 90 major power plants, including some of the most energy-efficient plants in the world, and are instrumental in the ongoing conversion from fossil fuels to biomass.

For our clients, working with Ramboll means that they will benefit from our long-term experience and know-how, and together we can transform complex challenges into solutions that are future proof, energy efficient, cost effective and practical.

INDEPENDENT ADVICE

- Owner's Engineer
- Lender's Engineer
- Project and programme manager
- Environmental advisor

LARGE RESOURCES

- Group 13,000 staff
- Energy 1,500 staff
- Power experts >240 staff

FULL SCOPE SUPPORT

- Feasibility & costing
- Specification, tendering & contracting
- Construction
- Commissioning
- O&M
- Life extension & upgrade
- Decommissioning & redevelopment

KEY EXPERTISE

- High efficiency power plants
- Biomass and bioconversions
- Cogeneration (CHP)



Number of major power plants designed and constructed by Ramboll

OUR ROLE IN THERMAL POWER PROJECTS

Ramboll has pioneered the development of innovative power plants with worldwide highest efficiencies and have particular expertise in:

- High efficiency power plants
- Biomass and bioconversions
- Cogeneration (CHP)

The Ramboll mind-set is to set and achieve the highest standards for health and safety throughout all stages of a project and subsequent plant operation.

Full project lifecycle services

We provide a comprehensive range of project lifecycle services ranging from strategic level to highly expert engineering specialisms.

Where projects involve wider infrastructure such as LNG facilities, ports etc. Ramboll is also able to deliver and integrate a complete range of project services.

Project development

The project development stage is of vital importance. It is at this time when key decisions are made on a project; this is the time to optimise to ensure the site selection, fuel type, technology and subsequent contracting methods considered are best aligned with the overall project objectives. If not addressed fully at the outset, subsequent optimisation and changes in later stages of a project can have significant cost and programme implications.

Owner's Engineer & EPCM

During project execution Ramboll provide Owner's Engineer and EPCM services to make sure the client's interests are best served. We ensure the appointed contractor(s) progress the plant design, manufacturing and subsequent construction and commissioning stages in line with the contract specification, programme and budget with the highest regard for health and safety.

O&M support

Ramboll has strong competencies within operation and maintenance, which enables our clients to make their operations more efficient and hence optimise the operating economy of their plant. Ramboll can assist with trouble-shooting on the entire power plant, from the inlet of the fuel through the delivery of power, steam and heating as well as the handling of residual products and flue gas.

Life extension

Lifetime extension of existing power plants can present an efficient way of meeting power generation needs whilst keeping investments at a manageable level. Ramboll's highly experienced experts identify how to extend the lifetime of power plants and seek out all possible improvements leading to increased plant efficiency, flexibility and availability and reduction of operational costs.

LIFE EXTENSION
 Assess plant for extension
 Feasibility studies & economic evaluation
 Tendering
 Project management
 Site activation



PROJECT DEVELOPMENT
 Feasibility studies
 Contractual analysis & PFI
 Contracting strategy
 Vendor assessment preparation
 Tender evaluation

Full project lifecycle services offered by Ramboll.

O&M SUPPORT
 Equipment performance monitoring
 Plant up to full capacity
 Fuel gas analysis & management
 Troubleshooting & plant safety

OWNER'S ENGINEER & EPCM
 Design & construction
 Equipment procurement
 Construction management
 Factory acceptance testing
 Start-up & commissioning
 Performance guarantee



**"RAMBOLL FU
UNDERSTOOD**

**THE MOST COMPLEX
PROJECTS AND PROACTIVELY
MET THE GOALS"**

DOUGHERTY

BIOMASS

Sustainable biomass offers a renewable low carbon alternative to fossil fuels for thermal power and heat generation.

Common fuels include manufactured wood pellets, grown crops, recovered residues, straw and various wastes.

Global leading experience

Ramboll has delivered biomass plants of all types and is a global leader in this area.

As well as developing multiple new biomass power and CHP plants, Ramboll staff pioneered the conversion of coal plants to biomass firing – at a time when there was no experience in the contracting supply chain.

Our experience of coal to biomass conversion is unparalleled. Our references are famous world-wide, and we continue to take a leading role globally.

Services

Ramboll offers all engineering services with respect to the planning, design, tendering, construction and operational phases for new build or upgraded power or CHP plants, fuelled by all types of biomass.

Optimising combustion

Biomass combustion can lead to fouling and corrosion of boiler heating surfaces as well as placing new demands on flue gas treatment systems and the disposal of the ash. Ramboll's expertise can help our clients to optimise the fuels and power generation systems that are critical for good efficiency and availability.

Delivering fire safety

Fuel system changes require consideration of fire safety (ATEX) and other health and safety issues.

Ramboll provides advice, risk management support and design solutions for all challenges arising.

Storage facilities

The main challenges in storage facilities stem from fire and explosion hazards.

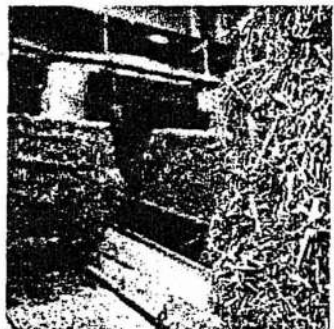
Ramboll is internationally recognised as the leading expert in the area of biomass related fire safety. We have invented and have a patent pending on a fire fighting concept which is highly suited for large wood pellets inventories.

Designing innovative solutions

Ramboll has designed highly automated bio fuelled power plants comprising automated straw reception and transport systems that only require man-power during receipt of straw.



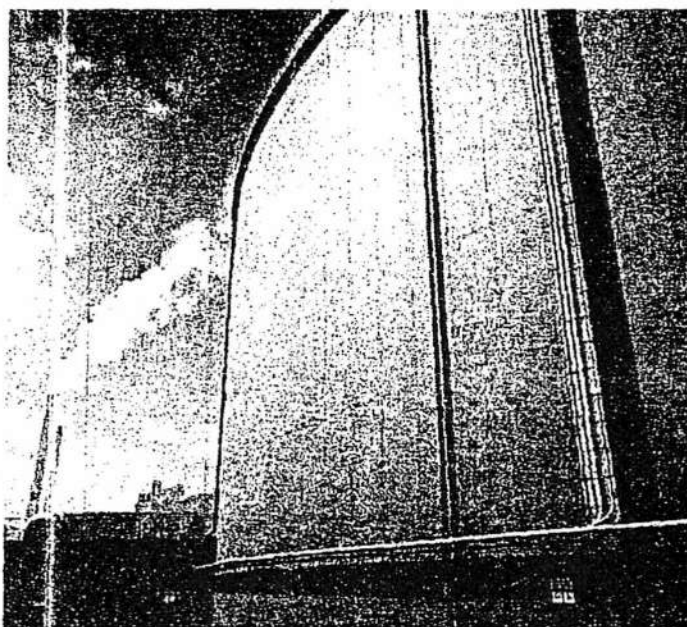
01



02

01. Manufactured wood pellets are globally traded and used for power and heat generation

02. Straw handling at a biomass CHP plant.

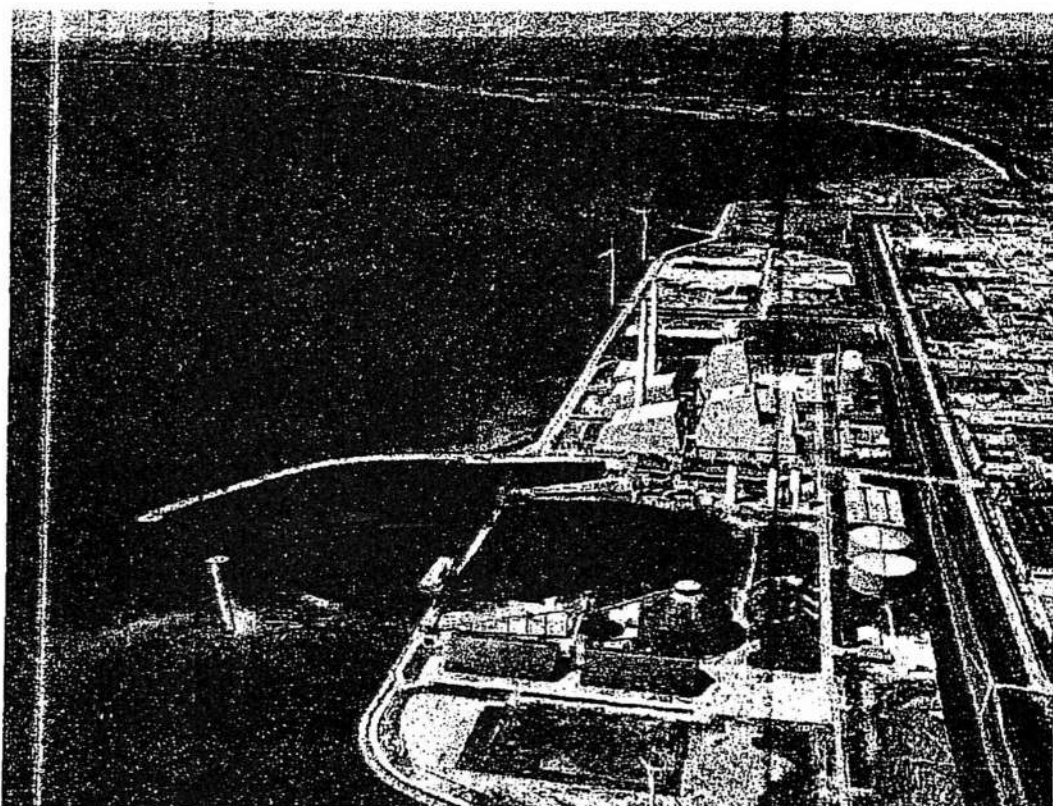


03

**03. AVEDØRE UNIT 2, DENMARK
575 MW**

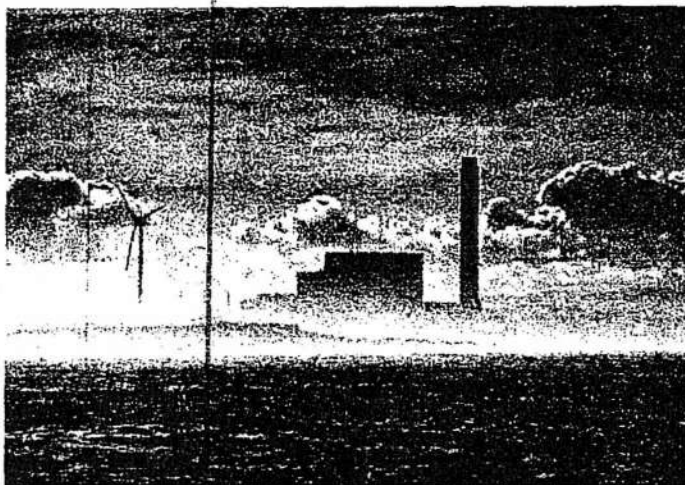
New biomass fuel storage silos. The fire detection and response system specifications were developed by Ramboll.

04. Avedøre Unit 2 is one of the world's most efficient multi-fuel power plants and has undergone 100% biomass conversion. Ramboll supplied development, design and expert engineering support to the Owner (DONG Energy) from concept to operation, covering all aspects from fuel handling & storage, to combustion & turbines, CHP systems, emission controls and residue management. Similar services are provided for the conversion of Unit 1.



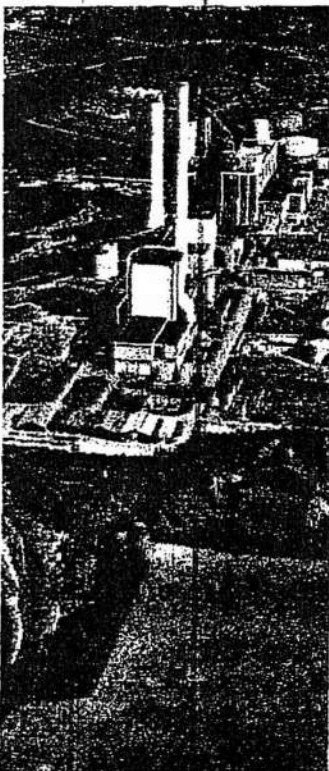
04

FEATURED BIOMASS REFERENCES



LYNEMOUTH, UK

420 MW full biomass conversion. Having supported the Owner at the development stage, Ramboll was appointed to provide support for the implementation of the project. In total the project comprises nine engineering packages, including an import terminal, site fuel handling and storage as well as the power plant conversion (Image: John Dalrymple).



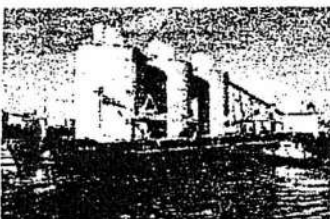
ASNÆS, DENMARK

Full biomass conversion of existing units and development of a 180 MW dedicated biomass fired power plant integrated into the existing power plant site.



STUDSTRUP UNIT 3, DENMARK

Full biomass conversion. Supplies 350 MW electricity and heat to the surrounding district heating system. Ramboll supported the plant's owner in all project phases from analysis through to commissioning.



GLADSTONE DOCK, LIVERPOOL, UK
Wood pellet import terminal with 100,000 tonne storage capacity. The plant is rail connected for fuel distribution. Ramboll was expert adviser to the construction contractor (Image: Drax).



**"RAMBOLL DEMONSTRATED
A STRONG AND DETAILED
UNDERSTANDING OF
THE SUBJECT MATTER AND
A GOOD APPRECIATION OF
THE ENVIRONMENT
WE ARE OPERATING IN."**

EDF ENERGY PLC

HIGH-EFFICIENCY POWER PLANTS

RAMBOLL OFFERS EXPERTISE IN:

- Ultra super critical plants
- Combined cycle and open cycle gas turbine plants
- Integrated solar thermal
- Multi-fuel applications
- Carbon capture and storage
- Advanced technologies such as gasification and oxyfuel

Thermal efficiency

Fossil fuel fired power plants continue to play a significant role in providing secure and affordable energy. Ramboll has specialist expertise which can reduce the carbon impact of fossil fuel power plants through the optimisation of thermal efficiency and deployment of state-of-the-art emissions abatement technology.

Efficient coal utilisation

The Nordjylland 3 Ultra Super Critical (USC) Power Plant, engineered by Ramboll, indeed holds the world record for most efficient coal utilisation, with an efficiency of over 47%. Ramboll achieved this through extensive insight and optimisation of the steam cycle and overall plant design.

Plant flexibility

Equally important for modern thermal plants is to operate highly flexibly, with a need to rapidly balance energy demands resulting from an increase in intermittent renewable energy sources. Ramboll has successfully engineered plant modifications which enable faster start-up times and greater cyclic operation.

USC plants

Ramboll has designed and realised some of the most efficient and fuel flexible thermal power plants in the world, applying the most advanced USC steam parameters and steam cycles. The plants are typically designed for coal, heavy fuel oil and/or natural gas.

Combined cycle plants

Our knowledge of Combined Cycle Gas Turbine (CCGT) plant concepts is extensive. Ramboll has realised some of the most efficient and flexible CCGT power plants in the world to date.

We can handle both relatively standardised CCGT projects and highly advanced CCGT projects involving customisation to fit specific requirements such as process steam supply for an industry, district heating supply or integration of a CCGT into an industrial process plant.

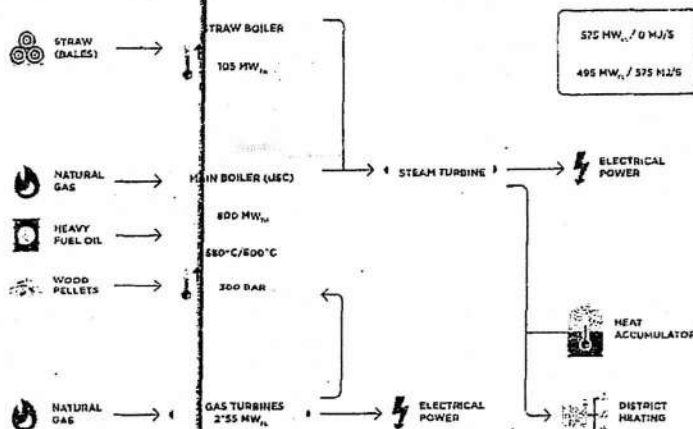
Our specialists have a combined working experience of realising more than 25,000 MW of CCGT plant capacities worldwide.

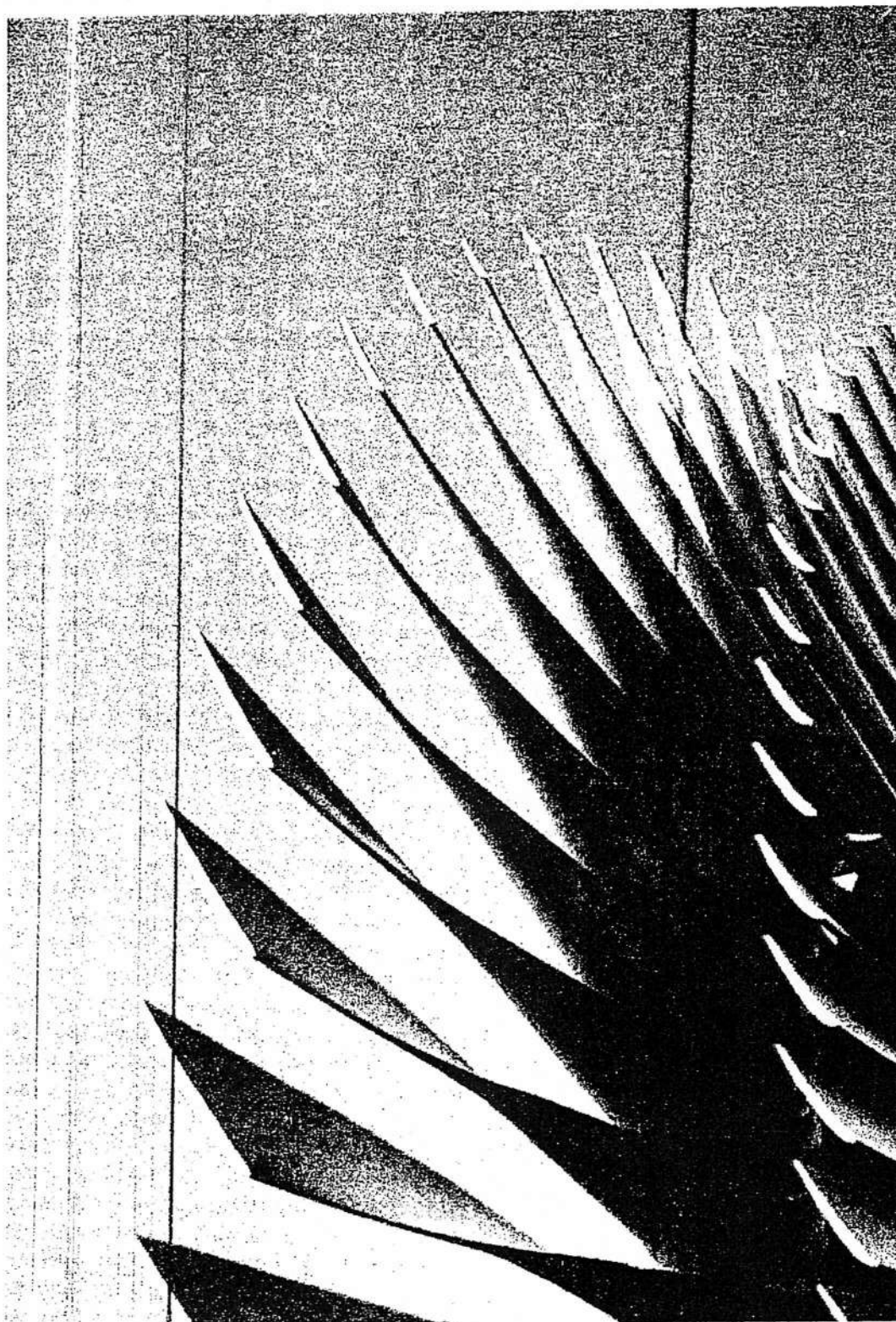
Multi fuel applications

Our ability to develop innovative power generation projects is ably demonstrated by our role in engineering and implementing the Avedore Unit 2 project which incorporates within an optimised thermal cycle:

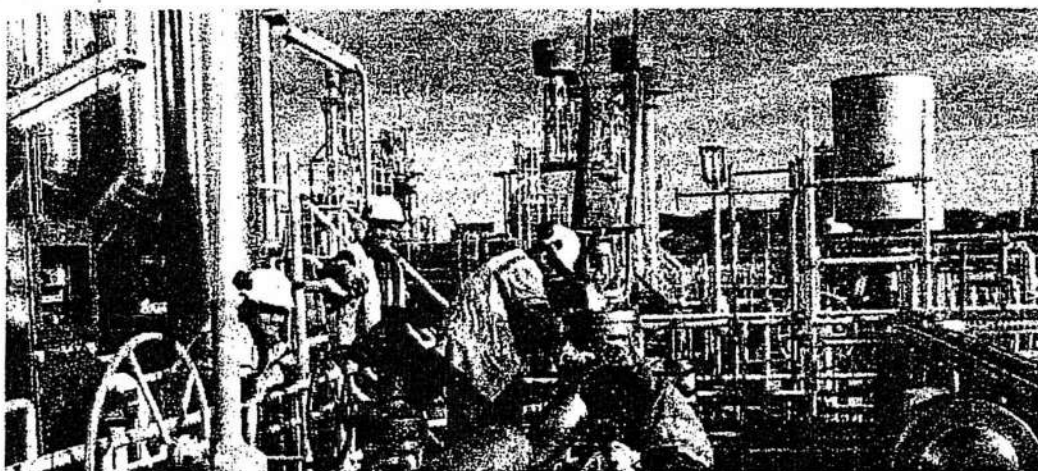
- USC multi fuel fired boiler
- Straw boiler
- Gas fired turbines in feed water cycle
- Energy storage heat accumulators

AVEDORE 2 - MULTI FUEL CONCEPT

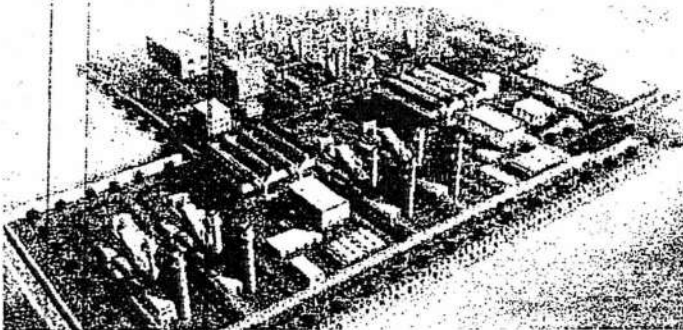




HIGH-EFFICIENCY POWER PLANT REFERENCES



MONGSTAD CCGT CHP PLANT, NORWAY
280 MWe + 350 MWth heat. Refinery integrated high efficiency CHP plant supplying high pressure steam and power. Ramboll staff acted as EPC Manager for the Owner during the plant development and construction.

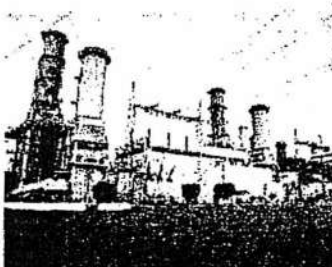


SALALAH II, OMAN
440 MW dual fuel CCGT natural gas/fuel oil. Ramboll was appointed to monitor construction and commissioning and to provide project co-ordination services.

KAPCO, PAKISTAN
Muzaffargarh 660 MW coal fired power plant. Ramboll was appointed to deliver the plant feasibility study, ESIA and EPC Contractor tender evaluation.



ENECOGEN, ROTTERDAM, NL
870 MW high efficiency gas CCGT. Ramboll's Owner's Engineer services included engineering design review, HAZOP, witness of testing, and review of O&M.





**"...IT GOES THAT
EXTENSIVE IN ANSWERING
ADDITIONAL QUERIES NOT
NECESSARILY COVERED BY
THE SCOPE"**

ANDY WOODWARD RWE

CO-GENERATION

Co-generation – also known as Combined Heat and Power (CHP) generation – increases the efficient use of fuel by supplying heat as well as power.

With power-only generation, low value energy is lost, but with CHP most of it is captured for use.

CHP can offer the advantage of reliable energy supply as well as lower carbon or renewable power and heat.

CHP systems also offer the possibility of district scale cooling systems, and can support the intermittency issues experienced with other renewables through energy storage.

Services

For both new and retrofit CHP projects Ramboll offers all services necessary for establishing optimised:

- CHP plants
- Energy storage
- Heat accumulators
- District & local heating systems
- District & local cooling systems

Our services range from planning, design and procurement to implementation and O&M support:

- Thermal modelling and optimisation
- Turbine design
- Heat accumulator design
- District heating systems design
- Plant generation and heat distribution system interface optimisations

Experience

Ramboll has been a leading consultancy in the development of both district heating, CHP conversion and new plant construction projects for more than 40 years.

Our vast experience with energy production facilities based on a variety of fuels combined with our experience of district heating transmission systems help us maximise the benefits for both investors and consumers.

KEY COMPETENCIES:

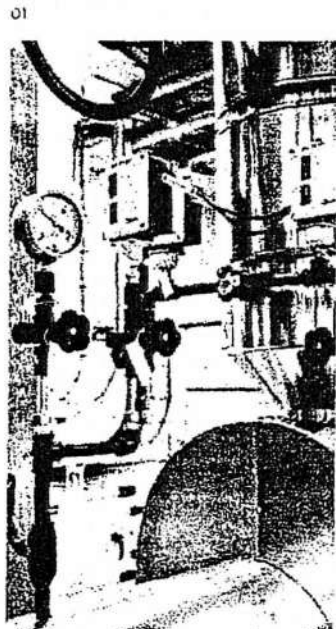
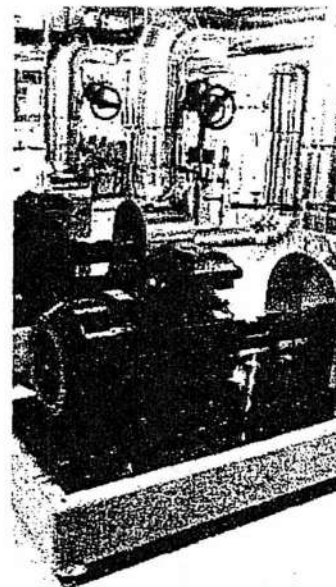
- Energy system planning
- Strategic studies
- Options appraisal
- Systems design
- Demand & supply capacity mapping
- Resource efficiency
- Carbon reduction

POWER PLANTS:

- Fuel handling
- Boiler design
- Process control
- Emissions control systems
- O&M
- Turbine design
- Heat exchangers & pumps
- Energy storage & heat accumulators

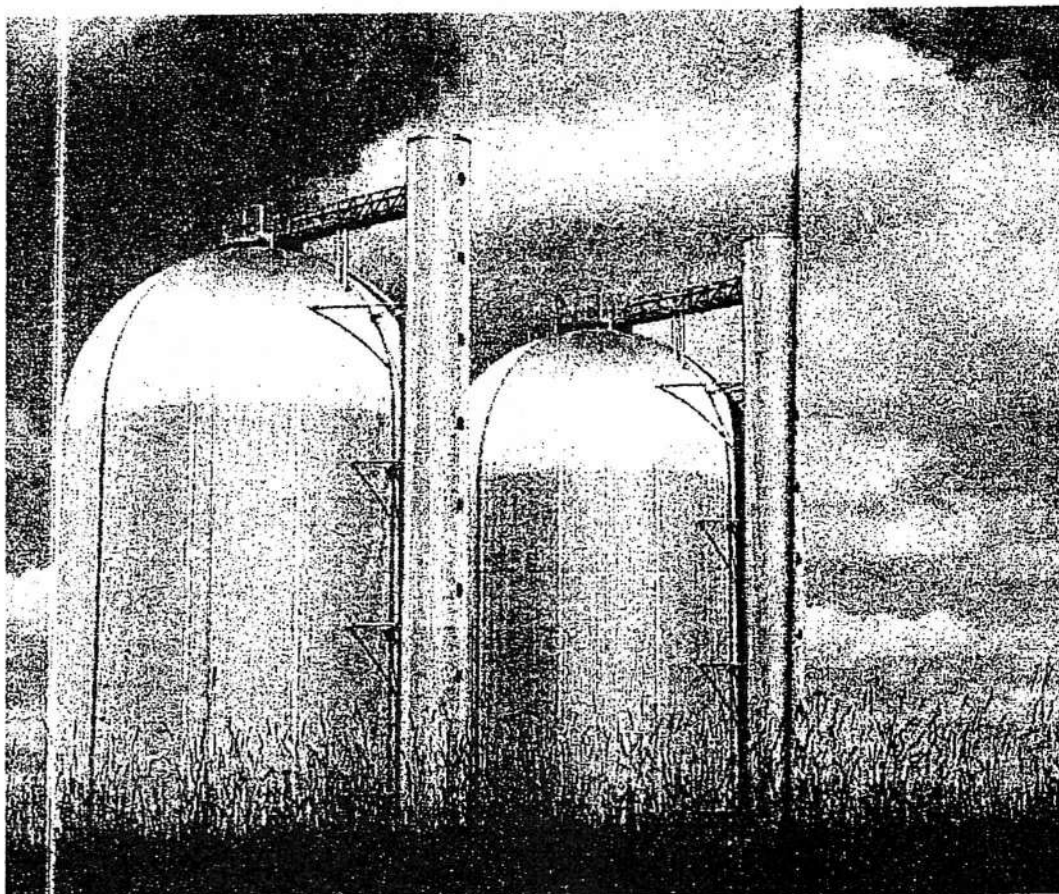
DISTRICT HEATING & COOLING:

- Transmission lines
- Distribution systems
- Auxiliary equipment
- End user connections

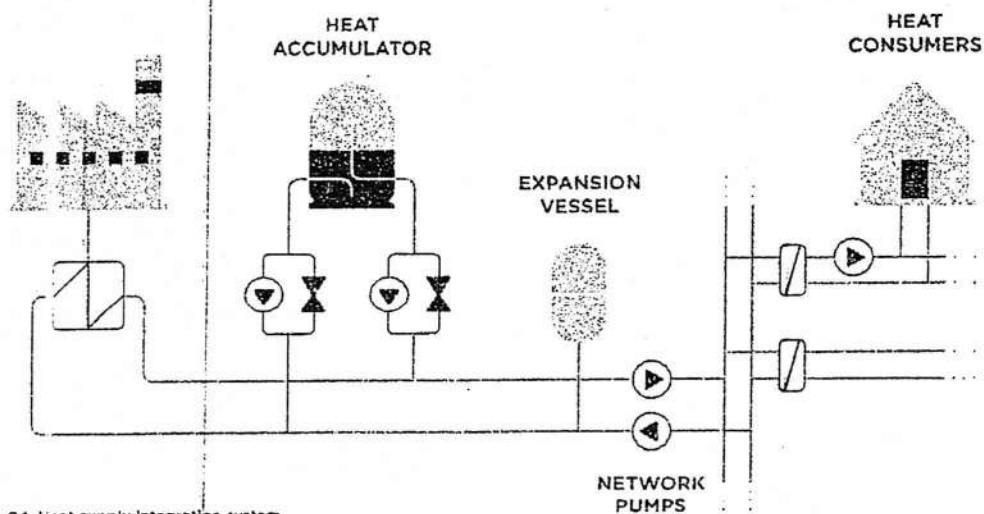


01 and 02. Gladsaxe, Denmark
Natural gas fired district heating peak load facility. Ramboll was lead consultant.

03. CHP accumulator tanks
Ramboll designed large-scale heat accumulators allowing the Avadore CHP plant to decouple heat and power production to optimise demand economics, and support a system with high wind power generation.



03



04. Heat supply integration system
The system provides renewable, low carbon heat to consumers linked to one of the world's largest integrated district heating systems.

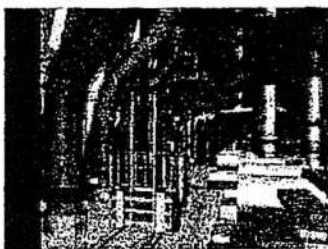
SPECIAL COMPETENCIES

Ramboll is unique amongst independent international power generation consultants, possessing highly expert competencies covering every aspect of power generation facilities and being able to offer clients a truly comprehensive range of specialist services.

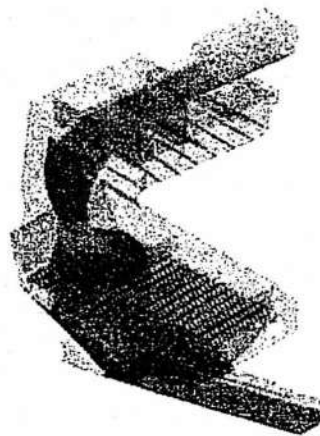
Alongside our project lifecycle services we provide specialist services at a detailed design and Front-End Engineering Design (FEED) level including a complete range of services to support plant operation, maintenance and lifetime extension.



Ramboll has developed an Online Process Optimisation system to enable plant operators to continuously identify areas impacting upon plant performance with remote specialist support on hand to assess significant performance deviations.



Using 3D scans, Ramboll provides designers with hundreds of thousands of coordinates in retrofit projects to optimise design and co-ordination.



With solid flow distribution modelling Ramboll can advise on detailed design modifications.

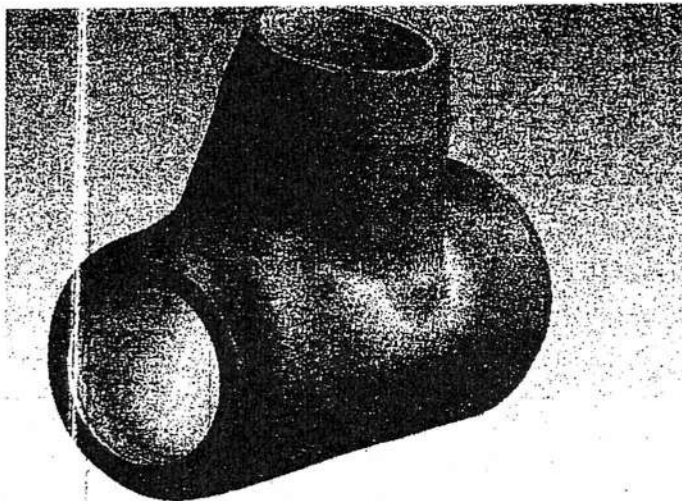
EXPERT COMPETENCIES

- Project Management
- Boiler, combustion and fuel logistics
- Turbine, process, balance of plant and cooling systems
- Power piping
- Environmental and emissions control
- Electrical power systems
- Instrumentation and control
- Civil engineering
- Site supervision
- QHSE & inspection services

Enabling
delivery of

SPECIALIST SERVICES

- Risk and process safety
- Boiler CFD modelling
- Creep damage and low cycle fatigue calculations
- Performance modelling and online process optimisation
- Root cause analysis
- Fire safety & ATEX
- Noise control engineering
- Vibration analysis and vibration protection
- Combustion and emissions performance optimisation
- Condition monitoring
- 3D modelling and laser scanning
- CE marking

**CREEP & FATIGUE CALCULATIONS**

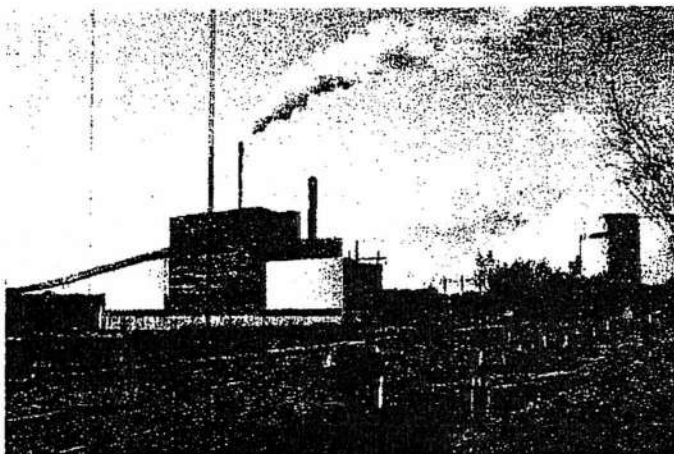
For many years, Ramboll specialists have been leading the way in refining fatigue and creep calculations in order to establish knowledge on the remaining lifetime of power plants. We have developed the unique software called Lifetex to perform exact calculations.

CFD BOILER MODELLING

Using our in-house CFD modelling expertise, Ramboll can assess the performance of new and existing boilers as well as develop designs and specifications for fuel and plant modifications.

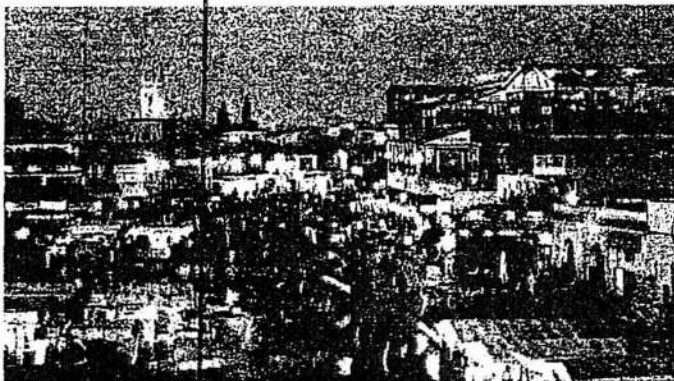


FURTHER REFERENCES



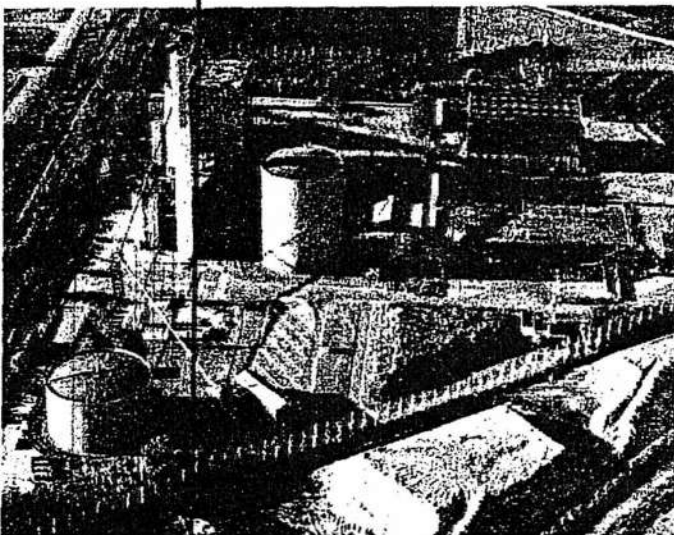
SANDVIK, VÄXJÖ, SWEDEN
40MWe + 60MWth biomass CHP plant.
Fuels include wood chips, bark, saw dust
and branches and roots.

Ramboll was the Owner's Engineer for the design and construction phase of a new biomass fired unit with technical responsibility for the boiler, turbine, flue gas cleaning and balance of plant. Our role commenced with the procurement of the major components, and then included monitoring of manufacturing, erection and commissioning as well as supervision of initial commercial operation and guarantee tests.



GAS-TO-POWER PROJECT, MOROCCO
LNG import terminal including storage
and maritime jetty, 2400 MW CCGT and
connecting gas pipelines.

Ramboll is the Technical Adviser to ONEE, working alongside legal and commercial advisers, with the responsibility to develop the project involving the definition of the institutional structuring of the project, preparation of feasibility studies and tender documents, evaluation of the offers, negotiation and contracting leading to the appointment of the company (ies) who will finance, construct and operate the Gas-to-Power project.



HERNING, DENMARK
97MWe 180MWth multi-fuel CHP plant.
This plant has been progressively adapted
over more than two decades and now
combines high efficiency with the capacity
for flexible firing of a full range of fossil
and biomass fuels, including wood pellets,
wood chips, oil, coal and natural gas.

Ramboll was the Owner's Engineer for all project phases from project analysis, design and planning to commissioning. Our technical input was provided across all parts of the plant from fuel delivery, storage and handling, to boiler and controls modifications, fire strategy and emissions control systems.

**ORION, DI-AKA AND KHULNA,
BANGLADESH**
2 x 630 MW high efficiency coal.

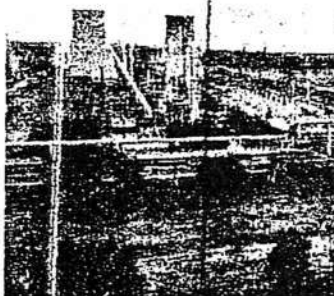
Large increases in power demand in developing countries result in the need for high efficiency solutions to permit development whilst limiting impacts.

Ramboll was chosen as the Owner's Engineer to ensure technical coherence and an optimised plant design comprising the highest possible overall efficiency of the plants.

Phases include input from pre-FEED and FEED to tendering and eventual construction and commissioning.



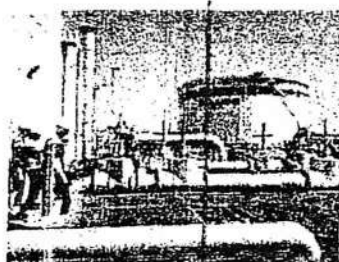
KILPILÄHTI POWER PLANT, FINLAND
The project involves the re-planting of thermal facilities at the largest refinery in the Nordic region. Ramboll was appointed as the Lender's Technical Adviser (LTA) covering technical, commercial and environmental aspects up to financial close. We continue as LTA during the construction and operational phases of the project.



PULAWY, POLAND
400 MW CCGT. A turn-key EPC project where Ramboll was appointed to provide Owner's Engineer technical support during procurement through to construction and commissioning stages. Services included review of tender specification, tender evaluation and Owner's Engineer services during project implementation.



SAUDI ARABIA, RABEC
1200 MW heavy-oil fired power plant. Ramboll executed root cause analysis (RCA) following tube failures and boiler CFD analysis to help select appropriate mitigation. Ramboll acted as independent adviser to the client.

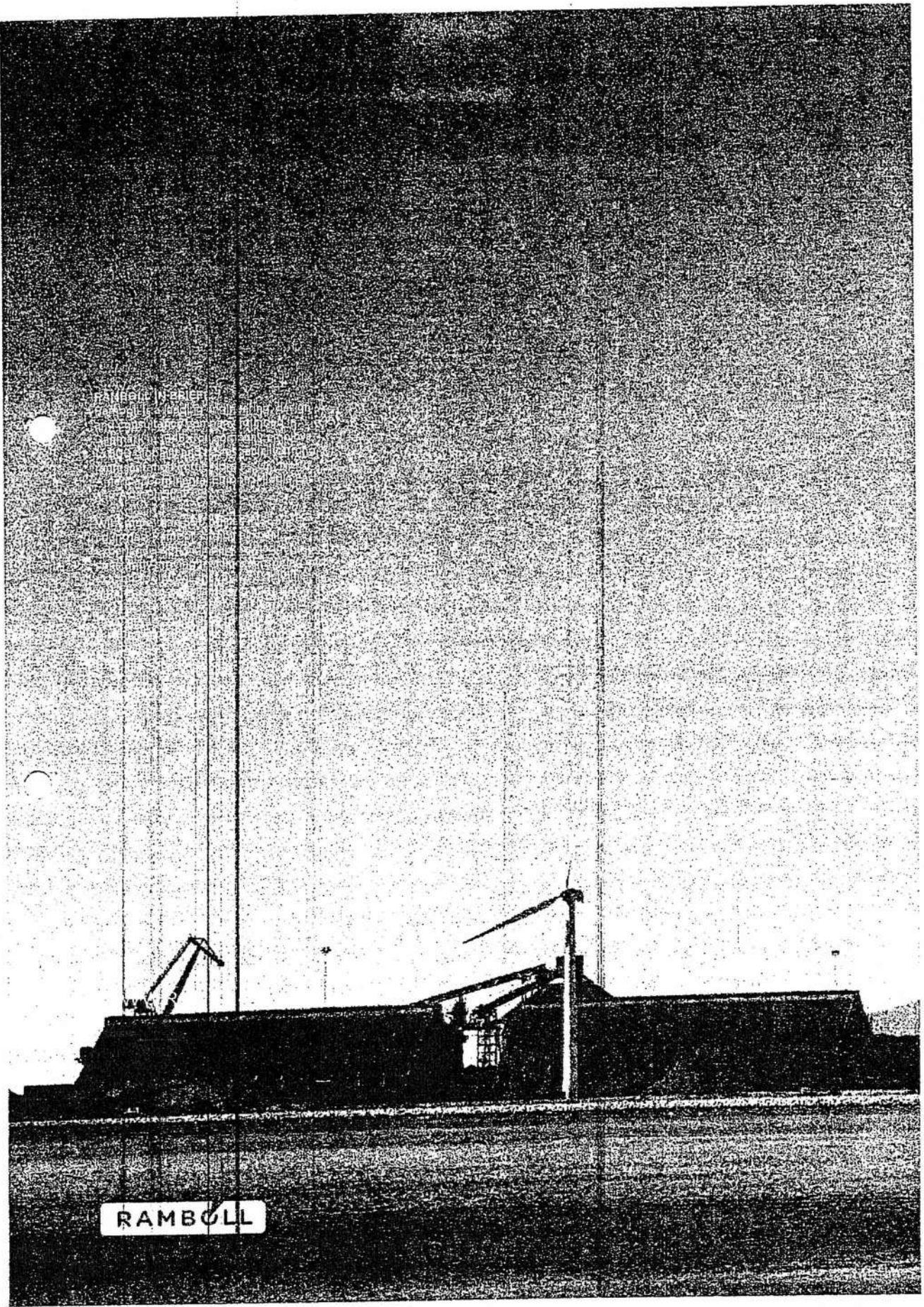


GUELPH, ONTARIO, CANADA
2 x 20MW new biomass CHP plus 1 x 7MW expansion.

Ramboll was appointed by the project developer to provide engineering support to determine the facilities' requirements, options and preliminary engineering design and cost for all three projects, including all mechanical and electrical services for the identified projects.

RAMBOLL IN BRIEF

RAMBOLL is a Danish
architectural and
engineering firm
founded in 1947.



RAMBOLL

ANNEXURE M
RULA STUDY REPORT

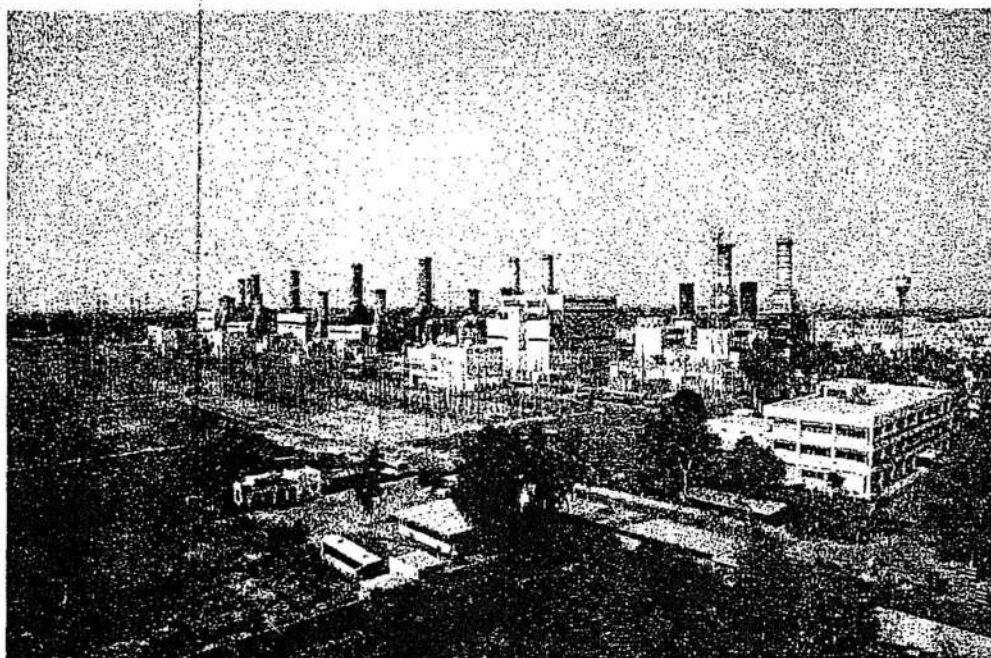
Intended for
Kot Addu Power Company

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Report

Date
June 2021

KAPCO PLANT REMAINING LIFE ASSESSMENT STUDY

Kot Addu Power Company Limited (KAPCO)



**Kot Addu, District Muzaffargarh
Pakistan**

KAPCO PLANT REMAINING LIFE ASSESSMENT STUDY

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Project no. 1620012420
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Appendix 1

REMAINING LIFE ASSESSMENT OF HRSGs

Appendix 2

UNIT TRANSFORMERS CONDITION MONITORING

Appendix 3

BUILDING & CIVIL STRUCTURE INTEGRITY ASSESSMENT

Appendix 4

ENVIRONMENTAL COMPLIANCE REPORT

Appendix 5

HISTORIC MAJOR MODIFICATION SUMMARY

Appendix 6

STRATEGIC SPARES LIST

Abbreviations

ADC	Annual Dependable Capacity Test
bar	Bars (pressure)
Bar(a)	Bars (absolute pressure)
Bar(g)	Bars (gauge pressure)
CDP	Compressor Discharge Pressure
CDT	Compressor Discharge Temperature
CW	Cooling water
CV	Calorific value
CCR	Central Control Room
CCGT	Combined cycle gas turbine
°C	Degrees Centigrade
COD	Commercial Operation Date
DPT	Dye Penetrant Test
EE	Exciter End
EOH	Equivalent Operating hours
FSR	Full Stator Rewind
Gas	Natural Gas
GT	Gas Turbine
HP	High pressure
LP	Low Pressure
HV	High voltage
HHV	Higher heating value
HSD	High Speed Diesel
HRSG	Heat Recovery Steam Generator
IDC	Initial Dependable Capacity Test 1996
IPP	Independent Power Producer
IEC	International Electro technical Commission
ISO	International Organization for Standardization
KAPCO	Kot Addu Power Company
kV	Kilovolt
km	Kilometer
kW/h	Kilowatt hour
kW	Kilowatt
KKS	Kraftwerk-Kennzeichen System
kJ	Kilojoules
LV	Low voltage
LHV	Lower heating value
L TSA	Long Term Supply Agreement
LSFO	Low Sulphur Furnace oil
MW	Megawatts
m	Meter

mm	Millimeter
mm WC	Millimeter of Water Column
MCR	Maximum continuous rating
m/s	Meters per second
m ³	Cubic meter
MV	Medium voltage
MW	Megawatts
m ²	Square meter
mbar	Milli bar
MJ	Mega joule
MPI	Magnetic Particle Inspection
MVA	Mega volt-amp
NDE	Non Destructive Examination
NDT	Non Destructive Testing
OH	Operating Hour(s)
OCGT	Open cycle gas turbine
O&M	Operating and maintenance
OEM	Original equipment manufacturer
OTC	Outlet Temperature Corrected
PM	Preventive Maintenance
PPA	Power Purchase Agreement
PSO	Pakistan State Oil
RUL	Remaining Useful Life
Si3D	Siemens Innovative 3-Dimensional design
SNGPL	Sui Northern Gas Pipelines Ltd
STG	Steam Turbine Generation Unit
sec	Second
TE	Turbine End
TET	Turbine Exhaust Temperature
TMCR	Turbine continuous maximum rating
t/h	Tones per hour
Unit	Gas Turbine or Steam Turbine Generation Unit
UT	Ultrasonic Testing
UTG	Ultrasonic thickness gauging
WAPDA	Water and Power Development Authority

Definitions

Commercial Availability: Availability of Plant excluding weighted Unscheduled Outages

Commercial Availability = ((Complex Capacity-Weighted Unscheduled Outage) x100)/(Complex Capacity)

Plant Availability: Availability of Plant excluding Schedule and Unscheduled Outages

Plant Availability = ((Complex Capacity- Scheduled Outages-Unscheduled Outages) x100)/(Complex Capacity)

1. EXECUTIVE SUMMARY

1.1. Introduction

Ramboll has been contracted by Kot Addu Power Company (KAPCO) to undertake a technical assessment of the remaining life of the KAPCO combined cycle power plant located at Kot Addu, District Muzaffargarh, Punjab in Pakistan. This assessment has been based on data provided to Ramboll by KAPCO which included plant O&M records and other 3rd party condition assessment reports, equipment inspections and NDT studies previously commissioned by KAPCO.

1.2. Rationales for Life Assessment Study

KAPCO combined cycle power Plant was built in phases from 1985 to 1996 by Water and Power Development Authority ("WAPDA"). It is the largest IPP operating in the mid country and supplying electricity through Six (6) 132 KV and Six (6) 220 KV feeders. KAPCO is the only CCGT power plant capable of operating on 3 types of fuel i.e. Gas, Low Sulphur Furnace Oil (LSFO) and High Speed Diesel (HSD). This multifuel capability makes KAPCO plant a backbone for the national grid.

Combined cycle power plant are typically constructed using a design life of 25-30 years. However, a specified Design Life does not necessarily dictate a finite life expectancy or mandatory retirement of the plant. Experience shows that the operating life can be enhanced by a further 15-20 years with the requisite capital expenditure and excellent maintenance practices.

KAPCO has an agreement of 25 years with power purchaser WAPDA that is expiring on 25 June 2021.

KAPCO units has been operating since past 25 to 30 years. It is necessary to assess aging impacts and to determine residual useful life of KAPCO generating units and auxiliaries so that for the same term PPA (Power Purchase Agreement) extension may be granted in sake of national interest as per clauses of extension within current PPA.

1.3. Scope and Methodology

Scope of study included residual life assessment of major equipment of CCGT plant e.g. Gas Turbine, Steam Turbine, HRSG, Generator, Unit Transformer, Instrumentation and Control System, Auxiliaries and Buildings and Structures.

This Life Assessment study has been conducted on the basis of Plant design data, Current Operating parameters, Units Operations and Maintenance History, Current operating performance, Life Assessment and NDT reports, condition monitoring test reports, Operator's own assessment in view of O&M challenges for the plant, World' Thermal Power plants Operating life trends and Ramboll's experience of power plant life extension projects.

Units have been studied Module wise (in configuration 2+1 i.e. two gas turbines and one steam turbine) for design data, technical limits, current operating conditions and parameters, past and current unit performance to develop a qualitative base line. World trends for plant life have been discussed.

The key aspects from recent major inspections, modifications, upgradations and condition monitoring test results have been reviewed.

Electrical major components e.g. Generator, Unit transformers healthiness and residual life has been assessed based on current offload/on load test results, NDTs and test results conducted during major inspections.

Important Auxiliaries and BOP equipment prone to aging, healthiness has been checked for residual life assessment.

Buildings and Civil structure integrity assessment reports has been reviewed for checking healthiness and fitness for units' future operations.

The main Plant components remaining life has been assessed based on design life, operating hours, NDTs and test results conducted during major outages and current unit conditions and with consideration to the experience of other life extension projects, globally.

The study has been concluded with remaining useful life assessment of the units along with recommendations.

1.4. Outline of KAPCO Plant Layout

KAPCO power plant comprises 10 Gas Turbines, 10 Heat Recovery Steam Generators (HRSG) and 5 Steam turbines. The Plant has been divided into 3 blocks, maintenance wise (Blocks 1, 2, 3) as well as efficiency wise in descending order Energy Blocks 1, 2 and 3. The Plant has been further subdivided into five modules with each module comprising two Gas turbines, two HRSGs and one Steam turbine. The five modules are Module-1; GT-1, GT-3 and STG-9; Module-2; GT-2, GT-4 and STG-10; Module-3; GT-5, GT-6 and STG-11; Module-4; GT-7, GT-8 and STG-12 and Module-5; GT-13, GT-14 and STG-15

1.5. Overview and Study of Plant for Qualitative Analysis

The design data and technical limits of the gas turbines, HRSGs and STG in each of the five modules have been discussed in regard to current O&M history and expected remaining life.

Units' current operating parameters have been investigated and compared with IDC parameters. Comparison has shown that all units are operating near to, or better, than IDC parameters. In spite of aging impacts on the units, all units' loading capacity in MW has been well maintained compared to IDC (Initial Dependable Capacity 1996). That is considered a direct consequence of excellent Operations and Maintenance strategy and Upgrades.

All Gas Turbine units can operate on all 3 fuels, Natural Gas, HSD and LSFO except GT-3 and 4 which can operate only on Gas and HSD.

GT-1, 2, 5, 6, 13, 14 and STG-9, 11, 12, 15 have undergone midlife control change.

GT-1, and GT-2 have undergone upgrade of the Inlet Guide Vanes (IGVs) from fixed to modulating to reduce stresses on turbine hot gas path components and to avoid compressor surge.

GT-3 has undergone replacement of the Excitation system with a new one. GT-3 and 4 HMI and Information system has been upgraded to Siemens Win CC.

GT-5 and GT-8 have undergone Hot Gas path up-gradation which has improved their exhaust temperature control curves i.e. increase in Turbine inlet temperature hence maintaining and improving loading Capacity.

GT-13 and GT-14 have undergone Siemens Si3D upgrades of the 1st two stages of the turbine. STG-10 has undergone installation of modified 1st stage moving blades for heat rate improvement and new LP turbine erosion protection rings of the last 3 stages.

All units' schedule outages e.g. MOH, HGPI and CI are being performed well in time as per OEM recommended intervals and/or criteria of OH, EOH and no. of starts.

Module wise average Plant Availability has been approximately 85% over the past five years which is excellent.

1.6. World trends in the Operating Life of Thermal Power Plants

World trends has been discussed in regard to thermal power plants, life cycle, deterioration impacts, maintenance strategies, World operating power plants life and age before retirements.

Operating life of a power station before decommissioning can be extended 20 to 25 years over the original design life in account of conservative design assumptions and well-managed repair and maintenance schedules including necessary capital expenditure to replace worn components.

In Europe, about 25000 MW of thermal power plants are in age range 30 to 60 years that is exceeding their design life of 30 years. The capacity-weighted average age of operating coal facilities in US is 39 years. In US, the most common age of recently retired Coal units is 50-60 years, Natural Gas Steam units 40-50 years, and for Combustion Turbine units it is 40-50 years.

The actual operating hours of a plant also needs to be considered as high-pressure, high temperature, components such as the heat recovery steam generators, main steam pipework, steam turbine are subject to material creep over an extended period of operation, in addition to the usual life limiting aspects of fatigue, erosion corrosion etc.

Whether thermal power plants are kept in operation, refurbished, placed on standby or decommissioned at their design life remains primarily an economic decision for the owner depending upon the unit condition and maintenance cost. More stringent environmental legislation may also be a deciding factor to retire a power plant if the environmental upgrade costs are too prohibitive. This has been the case for many of the coal-fired power plants in Europe.

1.7. Plant Major Components Remaining Life Assessment

Remaining life assessment has been discussed module wise for all major components of the units. Gas Turbine, Steam Turbine, HRSGs including main electrical equipment e.g. Generator, Transformers, condition monitoring tests has been discussed.

For all Gas turbine units, hot gas path components e.g. combustors, fuel nozzles, GT blades and vanes etc are being replaced periodically on HGPI and MOH as per OEM recommendation. One complete set of turbine blade/bucket and vane/nozzle is available in store as a strategic spare for each model of Gas Turbine at KAPCO.

Module-1 units: GT-1 last MOH was performed in Feb-March 2021. GT-3 last major inspection was performed in Feb-March 2018. STG-9 major overhaul was performed recently in Feb-March 2021. The overall condition of GT-1, GT-3 and STG-9 is satisfactory as analyzed from visual inspections, NDTs conducted during these outages e.g. DPT, Hardness testing, MPI and UT.

GT-1, GT-3 and STG-9 remaining life is assessed to be 10, 19 and 11 years respectively based on the current operating hours of each unit.

HRS-1 and 3 expected remaining life is assessed to be 12-15 years based on recent boiler inspection, NDTs and life assessment conducted by SGS in March 2021 for HRS-01. The condition of HRS-01 is considered to be representative of HRS-03 as HRS-03 has much lesser operating hours.

GT-1 Generator was overhauled in Feb-March 2021. Overall Generator condition is considered to be **Good** based on test reports e.g. ELCID, IR, and PI etc. During the inspection findings were observed on Generator rotor J Straps which were replaced with new. GT-3 Generator electrical tests and inspections conducted in October 2020 have shown healthy condition. It is considered that GT-1, and GT-3 Generators may be satisfactorily kept in operation for the next 10 years with condition monitoring.

GT-1 Unit Transformer life assessment tests were conducted on a sample basis in Block-1 and the test results are satisfactory. GT-3 Unit Transformers oil analysis reports are showing some paper aging. However, the overall condition of the Unit transformers is considered **Acceptable to Satisfactory**.

GT-1 is operating with a new control system with remaining life of 17 years. GT-3 control system is old yet operating satisfactorily with spares availability in KAPCO Stores.

ST-9 is of ABB design and manufacture, having a single flow HP and double flow LP cylinder. The steam turbine is rated at a nominal 112 MW with steam conditions of 46.9 bar and 495°C. The ST is directly coupled to an ABB air cooled generator of rating 132 MVA at 11 kV. A major turbine overhaul was performed recently in Feb-March 2021. The overall condition of the ST is considered to be **Satisfactory** as analyzed from visual inspections and NDTs conducted during these outages e.g. DPT, Hardness testing, MPI and UT. STG-9 control system was replaced with new SPPA-3000 in 2016. Generator overhauling was carried out in Feb-Mar 2021 and its condition is considered **Satisfactory** and may be kept in operation for next 10-15 years. Although the ST Unit Transformers oil analysis reports indicated some paper aging, the overall condition of the Unit transformers is considered **Acceptable to Satisfactory**.

Module-2 units: GT-2 and GT-4 minimum remaining life is assessed to be 11 and 19 years based on current operating hours and overall **Satisfactory** condition as observed from recent inspection reports.

HRS-2 and HRS-4 expected remaining life is assessed to be 12-15 years based on the above mentioned HRS-01 sample inspections, NDT and life assessment reports. HRS-1, 2, 3 and 4 are the same design from the same supplier.

GT-2 Generator was overhauled in Feb 2018. Siemens reported "No thermal or thermo mechanical aging phenomena were detected". It is considered GT-2 and GT-4 Generators may be satisfactorily kept in operation for next 10-12 years with scheduled condition monitoring checks.

GT-2 Unit Transformer life assessment tests were conducted in 2016 by ABB on a sample basis in Block-1 and test results were satisfactory. GT-4 Unit Transformer oil analysis report is showing satisfactory results. STG-10 Transformer oil analysis report is showing some degassing which will be tested again. However, operating parameters and electrical test results are normal and overall condition of the Unit transformers is considered to be **Satisfactory**.

GT-2 is operating with latest control system Siemens SPPA T3000 with minimum remaining life of 13 years. GT-4 and STG-10 control system is old yet operating satisfactorily with spares availability in KAPCO Stores. Moreover, control system spares obtained from STG-9 control system replacement are available for STG-10.

ST-10 is of ABB design and manufacture, having a single flow HP and double flow LP cylinder. The steam turbine is rated at a nominal 112 MW with steam conditions of 46.9 bar and 495°C. ST-10 is directly

coupled to an ABB air cooled generator of rating 132 MVA at 11 kV. A major overhaul of ST-10 was performed in Sep-Oct 2013. Modified 1st stage moving blades and Installation of new LP turbine erosion protection rings of the last 3 stages were installed during 2013. Overall condition is considered satisfactory based on a minor inspection carried out in 2016. Generator overhauling was carried in Feb-Mar 2016 and its condition is considered **Good** and the Generators may be kept in operation for the next 10-15 years with condition monitoring. STG-10 Unit Transformer oil analysis report is showing some degassing which will be tested again. However, operating parameters and electrical test results are normal and the overall condition of the ST-10 Unit transformer is satisfactory.

Module-3 units GT-5, GT-6 and STG-11 remaining life is assessed to be 14, 13 and 15 years based on the current operating hours and overall **Good** condition as observed from recent inspection reports of HGPI/MOH 2017 and Combustion Inspection March 2021.

HRSGs-11A, 11B, 12A and 12B are of same model. Life assessment of HRSG-11A and 11B has been conducted on sample basis in Nov 2020 and the same condition is predicted for the other two HRSGs. Based on life assessment report, routine maintenance inspections; HRSG-11A and 11B expected remaining life is greater than 15 years.

GT-5 and GT-6 Generators have been in service since commissioning. Based on monitoring test recommendation, conductive paint activity on stator winding has been carried out. Generator rotor flux report for GT-5 and 6 found **Satisfactory**. Full Stator rewind (FSR) material is available on site as strategic spare for GT-5, 6 and 7 Stators.

Generator rotor flux report indicates no significant fault and can continue its normal operation. Expected remaining life of the newly rewound STG-11 generator is considered greater than 15 years.

GT-5, 6 and STG-11 Unit TF Oil analysis reports indicate no internal fault and the condition is considered **Satisfactory**.

GT-5 and GT-6 are operating with GE's latest control system Mark VIe with remaining life of 17 years. The STG-11 control system ALSTOM ALSPA Controsteam V3 was upgraded in 2009 and the minimum remaining life is considered greater than 10 years.

ST-11 is of GEC Alstom design and manufacture, having a single cylinder (combined HP/LP). The steam turbine is rated at a nominal 103 MW with steam conditions of 40 bar and 511°C. The steam turbine is directly coupled to a GEC Alstom air-cooled generator of rating 121.64 MVA at 11 kV. A major overhaul of the turbine was performed in 2017. Overall condition is considered **Satisfactory** based on a minor inspection carried out in Feb-Mar 2020. A full Stator rewind was done in 2017 and its condition is considered **Very Good**. Generators may be kept in operation for next 15 years with regular condition monitoring checks. STG-11 Unit Transformer oil analysis report indicates the analyzed winding paper ageing markers (furans, methanol) have no significant paper ageing and thus quality of winding paper can be assessed as **Very Good**.

Module-4 units: GT-7, GT-8 and STG-12 remaining life is assessed to be 13, 12 and 14 years based on the current operating hours and the **Good** overall condition as observed from recent inspection reports 2021, 2019 and 2017 respectively.

GT-7 and GT-8 hot gas path upgradation was performed during outages in Sep-Oct 2010 and 2011 respectively.

Based on life assessment report (HRSG11A and 11B) in 2020 on sample basis, HRSG-12B previous report 2013 and routine maintenance inspections; HRSG-12A and 12B expected remaining life is considered greater than 15 years.

GT-7 Generator condition is considered **Satisfactory**, that is the same as for GT-5 and GT-6. A full stator rewind (FSR) material is available on site as strategic spare. GT-8 and STG-12 Generator full stator rewind was conducted in 2015 and the expected remaining life is greater than 15 years.

GT-7, GT-8 and STG-12 Unit Transformer Oil analysis reports and electrical tests and operating parameters indicate no internal fault and condition is considered **Satisfactory**.

GT-7 and GT-8 are operating with the old GE Speedtronic Mark IV control system which can be further operated reliably for next 10 to 12 years with the availability of control system spares in KAPCO stores and spares obtained from the control system replacement of GT5 and GT-6. STG-12 control system is ALSTOM ALSPA Controsteam V3 upgraded in 2011 and the remaining life is considered greater than 10 years.

ST-12 is of GEC Alstom design and manufacture, having a single cylinder (combined HP/LP). The steam turbine is rated at a nominal 103 MW with steam conditions 40 bar and 511°C. The steam turbine is directly coupled to a GEC Alstom air-cooled generator of rating 121.64 MVA at 11 kV. A turbine major overhaul was performed in 2015. The overall condition is considered **Satisfactory** based on a minor inspection carried out in Feb-Mar 2020. Full Stator rewind was done in 2015 and its condition is considered **Very Good**. The Generators may be kept in operation for next 15 years with scheduled condition monitoring. STG-12 Unit Transformer oil analysis report indicates the analysed winding paper ageing markers (furans, methanol) have no significant paper ageing and thus quality of winding paper can be assessed as **Very Good**.

Module-5 units: GT-13, GT-14 and STG-15 remaining life is assessed to be 10, 11 and 10 years based on the current operating hours and assessed condition.

Overall condition of units GT-13, GT-14 and STG-15 reported **Satisfactory to Good** during visual inspections and NDTs performed in the last MOH October 2019 and CI November 2020. NDTs performed during MOH included, Ultrasonic Testing, Magnetic Particle Test, Dye Penetrant Test and Hardness Test. HRSG-13 and 14 remaining life assessment conducted which included visual inspections and NDTs e.g. Ultrasonic thickness gauging, DPT, MPI, Hardness testing and Metallography.

Based on life assessment report which revealed no significant deterioration and routine maintenance inspections; expected remaining life of HRSG-13 and 14 is greater than 15 years.

GT-13 and GT-14 Generator condition is reported **Good** with minimum remaining life of 12-15 years on the basis of assessment tests conducted by Siemens.

GT-13, 14 and STG-15 Unit Transformer Oil analysis reports indicate no internal fault and condition is considered **Good** and remaining life is assessed 12-15 years.

GT-13, 14 and STG-15 Aux, HRSG-13 and HRSG-14 old control system has been replaced with new state of the art SPPA T3000 control system in Feb-March 2021. STG-15 control system already replaced to SPPA T3000. Hence the Control system can be operated reliably for further 15-20 years.

ST-15 is of Siemens design and manufacture, having two cylinders (single flow HP and double flow LP). This steam turbine is rated at a nominal 148 MW with steam conditions 57 bar and 528°C. The steam turbine is directly coupled to a Siemens air-cooled generator of rating 175MVA at 11kV. The overall condition of STG-15 is reported **Satisfactory to Good** during visual inspections and NDTs performed in

the last minor / major overhauling. STG-15 control system was replaced with new SPPA-3000 in 2015. STG-15 Generator condition is reported Good with minimum remaining life of 12-15 years on the basis of assessment tests conducted by Siemens. STG-15 Unit Transformer Oil analysis reports indicate no internal fault and condition is considered Good and remaining life is assessed 12-15 years. There is no indication of thermal or electrical faults reported in the transformer.

Cooling tower and Water treatment plant for all units are in healthy condition and can be kept in service for next 12-15 years. For cooling tower structure of the STGs water proofing and repairs have been performed.

Buildings and Civil structure integrity life assessment has been conducted for all units. Visual inspections and NDTs were conducted which included concrete compressive strength measurement by Rebound Hammer and Crack Depth Measurement by Ultrasonic Pulse Velocity Test and ultrasonic method. Identified cracks were repaired as recommended. Overall condition of civil structures and buildings is observed Satisfactory. We envisage remaining useful life of 20 years on the basis of a typical 50 years expected design life but assuming on-going condition assessment and maintenance being required.

1.8. Operations and Maintenance Practices

The Operations and Maintenance practices at the KAPCO Plant have been studied. Well established Local Procedures and Safety Rules are implemented at site to ensure safe and smooth operations of plant and safety of employees at work.

Maintenance management is working effectively through usage of Computerized Maintenance management system (CMMS).

Integrated Management system is implemented with accreditations of ISO9001 for Quality, ISO14001 for Environment and OHSAS18001 for Occupational Health and Safety.

KAPCO is complying all regulatory requirements in regard to Environment management system. All emissions of air, water and noise relating to plant operations are within limits established by Punjab Environment Protection agency.

Historic major modifications, upgrades and improvement projects are summarized which has ensured safe, reliable and efficient operations of plant along with human safety.

Spare inventory has been maintained in KAPCO stores for routine maintenance of units as well as for strategic spares for replacement of equipment if breakdown occurs.

Above 30,000 spare parts are stored in KAPCO Stores for Gas Turbines, Steam Turbines and Auxiliaries relating to Mechanical, Instrument and Electrical Equipment. This large volume of spares will help ensure the KAPCO Plant continues to achieve reliable operation and high Plant Availability in coming years.

1.9. Conclusion and Recommendations

Based on the O&M records, 3rd party condition assessment reports, qualitative and analytical study and life extension experience from other projects, it is Ramboll's opinion that the KAPCO Plant could continue to operate for a minimum further 10 years on the basis that the Plant continues to be operated as previous i.e. baseload and is maintained as per statutory and OEM requirements and the recommendations from recent, and future, plant inspections reports are implemented.

Module wise residual life assessment has been concluded as;

- a) **Module-1** (GT-1, GT-3 and STG-9) plant is in overall **Satisfactory** condition and expected Remaining life is assessed to be a minimum of 10 years. The following replacements/upgrades are recommended in the next MOH;
 - i. GT-1-3 replacement of air intake filters in case Differential pressure approaches upper limit
 - ii. STG-9 replacement of Row-1 blades
 - iii. HRSG-1-3 Insulation and Cladding to be replaced in next MOH from deteriorated surfaces.
 - iv. Cooling Tower structure inspections and repair with Tam Seal at portions showing corrosion effect
- b) **Module-2** (GT-2, GT-4 and STG-10) Plant is in overall **Satisfactory** condition and expected Remaining life is assessed to be a minimum of 10 years. The following replacements/upgrades are recommended in the next MOH;
 - i. GT-2-4 replacement of air intake filters as the Differential pressure approaches upper limit
 - ii. STG 10 replacement of Cooling Tower Fill material
- c) **Module-3** (GT-5, GT-6 and STG-11) Plant is in overall **Good** condition and expected Remaining life is assessed to be a minimum of 10 years. The following replacements/upgrades are recommended in the next MOH;
 - i. HRSG 11 A-B Flue Gases Ducts renovation due to aging factor, availing each shutdown opportunity
 - ii. STG-11 replacement of cooling tower fan blades
- d) **Module-4** (GT-7, GT-8 and STG-12) Plant is in overall **Good** condition and expected Remaining life is assessed to be a minimum of 10 years. The following replacements/upgrades are recommended in the next MOH;
 - i. GT-7 recommendation by OEM to replace compressor aft brush seals and honey-comb seals for better performance.
 - ii. STG-12 replacement of cooling tower fan blades and fill material
- e) **Module-5** (GT-13, GT-14 and STG-15): This is the highest efficiency CCGT plant in Pakistan which can also operate on LSFO. The Plant is in overall **Satisfactory to Good** condition and expected remaining design life is assessed to be a minimum of 10 years. The following replacements/upgrades are recommended in the next MOH;
 - i. Replacement of compressor blades for GT-13 and 14 (No finding reported till date)
 - ii. GT-13 and GT14 Corrosion Prevention Painting of filter house at external surface
 - iii. Repair of concrete structure of Cooling Tower and Clarifiers of STG-15
 - iv. Renovation of Thermal Insulation of GT-13 and GT14 and HRSG-13 and HRSG14
- f) **All Civil Buildings and Structures** integrity assessment has indicated overall condition to be **Satisfactory**, except some minor cracks and concrete corrosion. Expected Remaining useful life of Buildings and Structure is 20 years on the basis of 50 years design life.

2. INTRODUCTION

2.1. The Company

Kot Addu Power Company limited (KAPCO) Pakistan is the largest IPP of Pakistan with name plate capacity of 1600 MW. Kot Addu Power Plant (the "Power Plant") was built by the Pakistan Water and Power Development Authority ("WAPDA") in five phases between 1985 and 1996 at its present location in Kot Addu, District Muzaffargarh, Punjab. In April 1996, Kot Addu Power Company Limited ("KAPCO") was incorporated as a public limited company under the Companies Ordinance, 1984 with the objective of acquiring the Power Plant from WAPDA. The principal activities of Kot Addu Power Company limited (KAPCO) Pakistan are the ownership, operation and maintenance of the 1600 MW power plant at Kot Addu, Punjab Pakistan. The Company sells the electrical energy produced from its power plant to its customer, Central Power Purchasing Authority CPPA-G Pakistan.

The KAPCO power plant is Pakistan's largest combined cycle power plant and comprises 10 gas turbines, 10 heat recovery steam generators and 5 steam turbines. The power plant has the capability of using three different fuels to generate electricity, namely: Natural Gas, Low Sulphur Furnace Oil (LSFO) and High Speed Diesel (HSD).

2.2. Background

Combined cycle power plants are typically constructed using a design life of 25 - 30 years, with the design of civil structures up to 50 - 60 years. A number of hot, warm and cold starts are also specified together with the expected number of operating hours per year, typically 8,000 hours, which equates to a typical design life of 200,000 - 240,000 operating hours.

The hot gas path components need repair and replacing according to the OEM maintenance program several times during this plant design life calendar period.

Most combined-cycle power plants - regardless of scheduled gas turbine, steam turbine, and other major equipment O&M practices - display signs of aging and fatigue beyond 20 to 25 years of age after their initial commercial operation date.

Gas turbine, heat recovery steam generator and steam turbine components are exposed to stress caused by temperature or static and dynamic loading, low-cycle fatigue (LCF) and high-cycle fatigue (HCF), erosion, oxidation and high temperature corrosion as well as mechanical stress and wear. The high-pressure, high temperature, components also experience material creep over time.

Operating life can be enhanced further 15-20 years beyond design life with periodic replacements of major components as per ongoing maintenance schedule and refurbishment of equipment. Therefore 40-50 years is not an unusual operating life for a combined-cycle power plant.

A specified Design Life does not necessarily or inherently dictate a finite life expectancy or mandatory retirement of the plant and hundreds of power plants around the World have demonstrated economic operating life 15-20 years in excess of typical design life.

Replacement of control and instrumentation systems with new one, during midlife of power plant is typical refurbishment. Such new control and instrumentation equipment generally results from the obsolescence of much of hardware and the consequent lack of spares availability.

More frequent inspections, NDT and maintenance of the overall plant is usually required as a plant ages requiring repairs or replacement of components.

Throughout the plant operation, KAPCO generating units have demonstrated, high plant availability and enhanced plant performance in regard to both plant capacity as well as efficiency due to excellent maintenance schedules, OEM recommended upgrades and plant operations as per OEM guidelines.

Although Gas Turbine operations on Low Sulphur furnace oil in past several years has impacted in form of hot corrosion erosion and causes increased maintenance. In spite of these challenges, KAPCO power complex has maintained high availability factor. In the future, more generation is envisaged on Gas fuel due to supply of RLNG which will reduce maintenance.

KAPCO has followed best practices of Operations and Maintenance as advised by the equipment OEMs and adhered to the recommended periodic maintenance schedules. This has resulted in high plant availability and optimum plant performance.

Determining the amount of reliable residual useful life of the KAPCO generating units is very important so as to make firm commitments with the Power Purchaser, as unavailability under the Power Purchase Agreement has heavy financial consequences.

KAPCO Power purchase agreement of 25 years with the Power Purchaser CPPA (G) is expiring in June 2021, however, 16 months extension has been agreed as Other Force Majeure Event (OFME) under LD settlement agreement.

2.3. Objective

As the PPA term is ending in June 2021 and KAPCO is looking to continue business and serve the Country, it is important to conduct a study to ascertain the useful Residual life of KAPCO units so that PPA Term renewal can be negotiated accordingly.

2.4. Scope of Work

Scope of Study includes Residual life assessment of all KAPCO units and related major equipment;

- Gas Turbine
- Steam Turbine
- HRSG
- Generator
- Unit Transformer
- Instrumentation and Control System
- BOP and Auxiliaries e.g. Cooling Tower, Water Treatment Plant
- Buildings and Structures

2.5. Approach and Methodology:

This Life Assessment study has been conducted on the following basis;

- 1- Plant Design data and OEM recommendations
- 2- Units Operations and Maintenance History
- 3- Plant Current Operational Data
- 4- Plant Current Environment Performance Data
- 5- Plant Major upgrades and replacements
- 6- Plant Components NDTs conducted during major outages
- 7- Life assessment reports as conducted by third party during Major Outages
- 8- Plant routine Operational and Safety Tests
- 9- Electrical systems routine tests, major outages testing and condition monitoring tests
- 10- Operator's experience for plant operations and maintenance
- 11- Plant Current O&M Practices and Procedures
- 12- World's Thermal power industry standards and best practices
- 13- Ramboll's experience of life extension projects

2.5.1. Life Assessment Methodology:

The following methodology has been adopted for Life Assessment study of the KAPCO units;

- Review of the technical design and present condition of the KAPCO units.
- Review of operating records, units operating and maintenance history
- Review of Current Plant Performance vs design Performance to assess aging impact
- Theoretical analyses on design criteria and operational experience from similar units and components in the World
- Module wise detailed analysis of major components for residual life
- Review of 3rd party inspection reports and non-destructive testing (NDT) conducted during recent major outages of critical components e.g. for HRSG life assessment during MOH which includes, Dimension checks, Hardness tests, Replica extraction, Magnetic particle test, ultrasonic examination, etc.
- Review of 3rd party Generator and other major electrical components on-load and off-load testing and NDT reports.
- Review of 3rd party reports for inspections and testing of major /critical structures i.e. foundations of the Gas/Steam Turbine and Generator, Cooling Towers, etc.
- Review 3rd party reports for the technical design and present conditions of, Generator, Transformers, Auxiliaries and BOP for the assessment work.

3. OUTLINE OF KAPCO PLANT LAYOUT

KAPCO power plant consists of five modules as per plant configuration. Each module consists of two Gas Turbines, two HRSGs and one steam turbine. Maintenance wise the Plant has been divided into Maintenance Block-1, 2 and 3. Similarly, efficiency wise the Plant has been divided into Energy Block-1 (which is the highest efficiency), Energy Block-2 and Energy Block-3 (which is least efficient block). Below is the plant layout as per configuration mentioned herein;

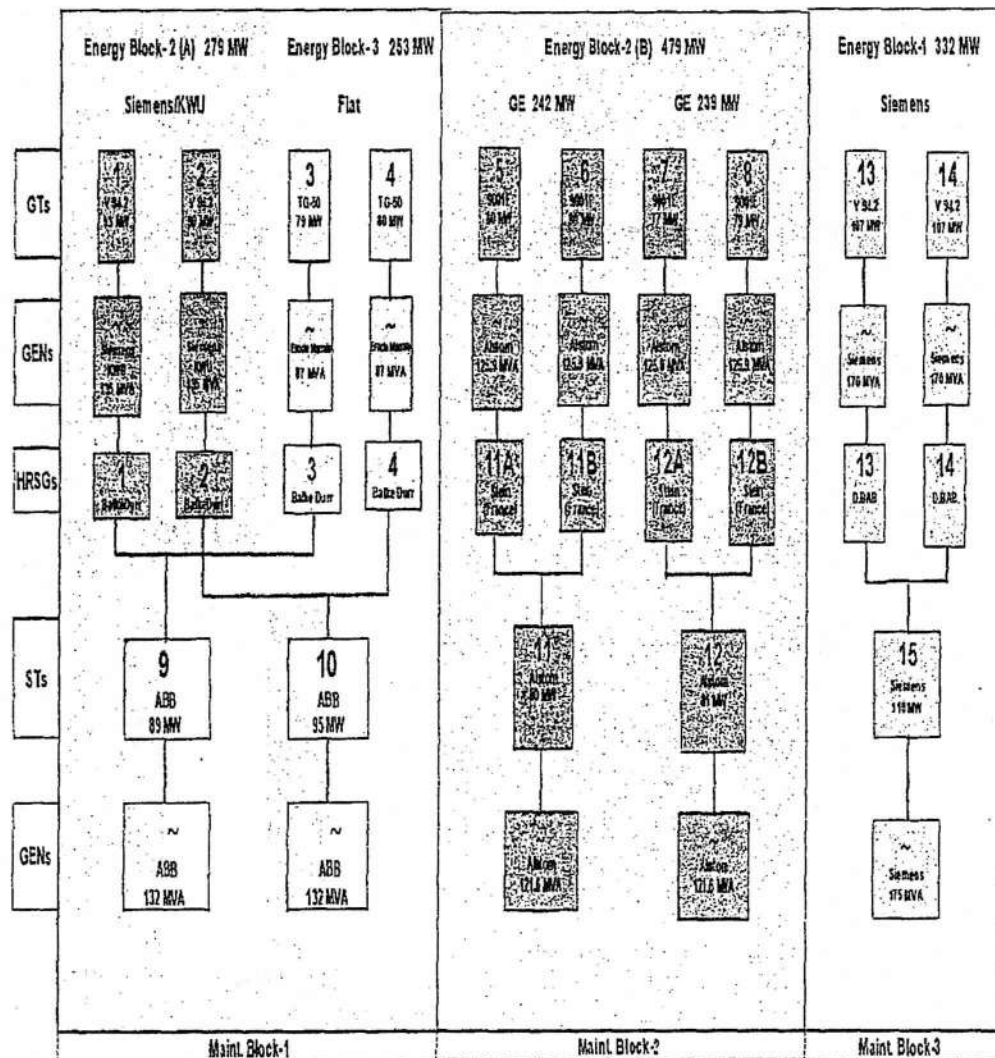


Figure 3- 1 KAPCO Plant Layout

4. OVERVIEW AND STUDY OF KAPCO GENERATION UNITS

4.1. Overview of KAPCO Module-1

KAPCO Module-1 consists of two gas turbines, two heat recovery steam generators (HRSGs) and one steam turbine. Gas turbine GT-1 is Siemens V94.2 type and was commissioned in January 1987 in open cycle mode on HSD fuel.

Gas turbine GT-3 is Fiat TG50D type and was commissioned in March 1987 in open cycle mode on HSD fuel.

Module-1 open cycle gas turbines GT-1 and GT-3 were converted to combined cycle mode after commissioning of Heat Recovery Steam Generators; HRSG-1 and HRSG-3 along with steam turbine STG-9 in 1991.

GT-1 was commissioned on Furnace oil and Gas in 1991. GT-3 was also commissioned on Gas fuel in February 1991. GT-3 cannot operate on Furnace oil.

Module-1 configuration is as follows: GT-1 + HRSG-1, GT-3 + HRSG-3 and STG-9

4.1.1. Design and Current Operating conditions of Module-1 Units:

4.1.2. Design Data and Technical Limits of Module-1 Units:

Gas Turbine GT-1 has operated satisfactorily since its commissioning in 1987 with periodic replacements of hot gas path components as per the OEM recommended maintenance cycle. Below is the design data of GT-1 which is valid for current unit operation;

Table 4.1: GT-1 Design Data

Sr. No.	Description	GT-1
1.	Model	V-94.2
2.	Manufacturer	KWU(Germany)
3.	Base Load rating at 15°C	125.5 MW (HSD)
4.	Starting time up to 3000 RPM	4 Minutes
5.	Turbine Inlet Temp	1050°C
6.	Turbine Exhaust Temp at full load	507 to 550°C
7.	Auto loading gradient	i. 11 MW/minute up to base load ii. Onward 4 MW/Min
8.	Overall Efficiency	28.8 %

Initially GT-1 had fixed position IGVs which were then upgraded to be modulating IGVs in 2005 to reduce thermal stresses and to control compressor surge.

GT-1 Control system has been replaced from the old ISKMATIC to a modern Siemens SPPAT3000 in 2016 to enhance unit reliability.

Gas Turbine GT-3 has operated satisfactorily since its commissioning in 1987 with periodic replacements of hot gas path components as per the OEM recommended maintenance cycle. Below is the design data of GT-3 which is valid for current unit operation;

Table 4.2: GT-3 Design Data

Sr. No.	Description	GT-3
1.	Model	TG-50D
2.	Manufacturer	GIE(Italy)
3.	Base Load rating at 15°C	96.08 MW (HSD)
4.	Starting time up to 3000 RPM	25 Minutes.
5.	Turbine Inlet Temp	1050°C
6.	Turbine Exhaust Temp at full load	553 to 610°C
7.	Auto loading gradient	6 MW/Min
8.	Overall Efficiency	27.4 %

Steam Turbine STG-9 is of ABB make and has operated satisfactorily since its commissioning in 1991. Below is the design data of steam turbine Unit-9 which is still valid for current unit operation;

Table 4.3: STG-9 Design Data

Sr.No.	Description	Units STG-9
1.	Make	ABB, Germany
2.	Type	DK2056
3.	Rated Power	112.2 MW
4.	Live Steam (for steam turbine) Inlet Press	47.9
5.	Live Steam Temperature °C	495
6.	Secondary Steam (for de-aeration) Inlet	3.99
7.	Secondary Steam Temperature °C	190.6
8.	Vacuum (Bar)	0.091

9.	Generator rating	132 MVA @ 50 Cold Air Temp
10.	Unit Transformer rating	135 MVA

Heat Recovery steam generators HRSG-1 and HRSG-3 are in operation since COD 1991 without any major problems. Below is the design data for HRSG-1 and HRSG-3 which are operating at design capacity.

Table 4. 4: HRSG-1 and HRSG-3 Design Data

HRSG-1, Balke Durr	
Steam Flow	208 t/h
Design Pressure	62 bar(g)
Superheater Outlet Pressure	47.1 bar(g)
Superheated Steam temperature	505°C
Total Heating Surface	58180 m ²
HRSG-3, Balke Durr	
Steam Flow	180.8 t/h
Design Pressure	62 bar(g)
Superheater Outlet Pressure	48 bar(g)
Superheated Steam temperature	500°C
Total Heating Surface	54182 m ²

4.1.3. Current Operating Data of Module-1 Units

Following data of Annual Dependable Capacity Test performed on dated 01-07-2020 shows that Module-1 units are operating near to or better than IDC parameters (IDC Initial dependable Capacity Test 1996) owing to prudent operating procedures and excellent maintenance strategy;

Table 4.5: Module-1 Operating Data

Gas Turbine No. 1 at 36°C ADC & 34°C IDC ambient temperature on LSPG							
Reading	Real Load	Reactive Load	CDP	CDT	OTC	Inlet Loss	Exhaust Loss
	MW	MVAR	bar	°C	°C	Pascal	mbar
ADC-2020	94	19	8	342	488	500	21
IDC-1996	90.0	-7.4	8	340.0	488	600	21.0
Gas Turbine No. 3 at 36°C ADC & 34°C IDC ambient temperature, ADC on Gas & IDC on HSD							

Reading	Real Load	Reactive Load	CDP	CDT	TET	Inlet Loss	Exhaust Loss	
	MW	MVAR	bar	°C	°C	mm of H2O	mbar	
ADC-2020	77	25	10	399	582	122	19	
IDC-1996	80	17	9	397	576	71	13	
Steam Turbine No. 9								
Reading	Real Load	Reactive	HP Inlet	HP Inlet	Ex Press	CW Inlet	Cooling Tower Fans	
	MW	MVAR	Press bar	Temp °C	bar	Temp °C	in service	
ADC-2020	101	23	41	493	0.11	32	6	
IDC-1996	92	2	42	480	0.235	32	6	
HRSG-1				HRSG-3				
Reading	HP Steam	HP Steam	FW Inlet	Flue Gas	HP Steam	HP Steam	FW Inlet	Flue Gas
	Press bar	Temp °C	Temp °C	Temp °C	Press bar	Temp °C	Temp °C	Temp °C
ADC-2020	42	487	119	181	42	498	117	147
IDC-1996	41	480.6	130	192	42	497.8	132	160

4.1.4. Operating Record of Module-1 Units

Following data shows operating hours, No. of starts, trips of module-1 units since commissioning till 31 March 2021.

No. of starts are higher for GT-3 in regard to its total Operating hours <100,000.

Table 4.6: Operating Record Module-1

Module-1 Operating Record since Commissioning to March 2021			
	GT-1	GT-3	STG-9
Date of commissioning	18-Jan-87	12-Mar-87	28-Jan-91
Total No. of Starts	3862	4612	2600
Operating Hours (OH)	171801	93920	165469
No. of Trips	311	113	180

4.1.5. Maintenance Record and History of Module-1 Units

Module-1 Units are operated at base-load, within the original equipment manufacturer (OEM) guidelines. Depending upon the Equivalent Operating Hours of the unit, the following periodic maintenance tasks are performed:

Gas turbines:

- Combustion inspection
- Hot gas path inspection (Not needed for GT-1 as per OEM recommendation)
- Major Overhauling

Generators:

- Schedule inspection every year
- Major inspection after every 60000 EOH

Steam turbine:

- Minor Overhauling/Inspection/Borescope examination
- Major Overhauling

GT-1 and GT-2 combustion inspections are executed by the KAPCO team whilst the MOH is executed by Siemens' Engineers. As per the maintenance life cycle, all spare parts used for replacement are supplied by the OEM, Siemens, in accordance with LTSA (Long Term Supply Agreement).

For GT-3 and GT-4 all maintenance tasks are performed by the KAPCO team. Spares are supplied by Ethos Energy (successor of Fiat).

Table 4.7: Maintenance Record Module-1

ACTIVITY	DATA ITEMS	GT-1	GT-3	GT-4
COMBUSTION INSPECTION	Last CI Inspection Dates	01-Feb-21	01-Sep-19	-
		To	To	-
		31-Mar-21	08-Sep-19	-
HOT GAS PATH INSPECTION/MINOR OVERHAULING	Last HGPI Dates	-	11-Feb-18	01-Feb-21
		-	To	To
		-	27-Mar-18	31-Mar-21
MAJOR OVER HAULING	Last MOH Dates	01-Feb-21	11-Feb-18	01-Feb-21
		To	To	To
		31-Mar-21	27-Mar-18	31-Mar-21

4.1.6. Operating Performance of Module-1

Below is the past five years operating performance of the Module-1 Units which shows that the Units are operating with best commercial performance figures with high availability factor.

Average plant availability factor of above 85% and Commercial availability of above 95% is comparable to new plants in the power market.

Table 4.8: Operating Performance of Module-1

Gas Turbine GT-1		
Year	Plant Availability %	Commercial Availability %
2015-16	75	94
2016-17	91	97
2017-18	92	97
2018-19	93	98
2019-20	94	97
Average	90	97
Gas Turbine GT-3		
Year	Plant Availability %	Commercial Availability %
2015-16	76	94
2016-17	90	95
2017-18	83	97
2018-19	84	98
2019-20	93	97
Average	87	96
Steam Turbine STG-9		
Year	Plant Availability %	Commercial Availability %
2015-16	74	94
2016-17	90	96
2017-18	87	97
2018-19	88	97
2019-20	93	97
Average	88	96

4.1.7. Qualitative Conditional Assessment of Module-1 Units

Following is the qualitative conditional assessment of Module-1 Units;

Table 4.9: Qualitative Conditional Assessment

Unit #	Operating Parameters Maintained per IDC	Schedule Maintenance Performed	Upgraded	Upgrade Type	Spares Inventory Maintained	Overall Condition Rating	Overall Unit Condition
GT-1	Yes	Yes	Yes	-IGVs Modulating - Control Change	Yes	8	Satisfactory
GT-3	Yes	Yes	Yes	New Excitation System	Yes	6	Acceptable
STG-9	Yes	Yes	Yes	Control system Change	Yes	8	Satisfactory
HRS-1	Yes	Yes	No	NA	Yes	8	Satisfactory
HRS-3	Yes	Yes	No	NA	Yes	9	Good
Condition Rating Criteria 1-10: Rating 9-10 = Good; Rating 7-8 = Satisfactory; Rating 4-6 = Acceptable; Rating 1-3 = Unacceptable							

4.2. Overview of KAPCO Module-2

KAPCO Module-2 consists of gas turbines GT-2 and GT-4, heat recovery steam generators HRSG-2 and HRSG-4 and steam turbine STG-10. Gas turbine GT-2 of Siemens V94.2 type was commissioned in January 1987 in open cycle mode on HSD fuel.

Gas turbine GT-4 of Fiat TG50D type was commissioned in May 1987 in open cycle mode on HSD fuel.

GT-2 was commissioned on furnace oil and gas in 1991. GT-4 was also commissioned on gas fuel in February 1991. GT-4 cannot operate on furnace oil.

Module-2 open cycle gas turbines GT-2 and GT-4 were converted to combined cycle mode after commissioning of HRSG-2 and HRSG-4 along with steam turbine STG-10 in 1991.

Module-2 configuration is as follows: GT-2 + HRSG-2, GT-4 + HRSG-4 and STG-10

4.2.1. Design and Current Operating conditions of Module-2 Units:

4.2.2. Design Data and Technical Limits of Module-2 Units

Gas Turbine GT-2 is in operation satisfactorily since its commissioning in 1987 with periodic replacements of hot gas path components as per OEM recommended maintenance cycle. Below is the design data of GT-2 which is valid for current unit operation;

Table 4.10: Design Data of GT-2

Sr. No.	Description	GT-2
1.	Model	V-94.2
2.	Manufacturer	KWU(Germany)
3.	Base Load rating at 15°C	125.5 MW (HSD)
4.	Starting time up to 3000 RPM	4 Minutes
5.	Turbine Inlet Temp.	1050°C
6.	Turbine Exhaust Temp at full load	507 to 550°C
7.	Auto loading gradient	i. 11 MW/minute up to base load ii. Onward 4 MW/Min
8.	Overall Efficiency	28.8 %

Initially GT-2 had fixed position IGVs which were then upgraded to be modulating IGVs in 2005 to reduce thermal stresses and to control compressor surge. The GT-2 Control system has been replaced from the old ISKMATIC to a modern Siemens SPPAT3000 in 2013 to enhance unit reliability.

Gas Turbine GT-4 has operated satisfactorily since its commissioning in 1987 with periodic replacements of hot gas path components as per the OEM recommended maintenance cycle. Below is the design data of GT-4 which is valid for current unit operation;

Table 4.11: Design Data of GT-4

Sr. No.	Description	GT-4
1.	Model	TG-50D
2.	Manufacturer	GIE(Italy)
3.	Base Load rating at 15°C	96.08 MW (HSD)
4.	Starting time up to 3000 RPM	25 Minutes.
5.	Turbine Inlet Temp	1050°C
6.	Turbine Exhaust Temp at full load	553 to 610°C
7.	Auto loading gradient	6 MW/Min
8.	Overall Efficiency	27.4 %

Steam Turbine STG-10 is of ABB make and has operated satisfactorily since its commissioning in 1991. Below is the design data of steam turbine unit-10 which is still valid for current unit operation;

Table 4.12: Design Data of STG-10

Sr. No.	Description	Units STG-10
1.	Make	ABB, Germany
2.	Type	DK2056
3.	Rated Power	112.2 MW
4.	Live Steam (for steam turbine) Inlet Press (Bar)	47.9
5.	Live Steam Temperature °C	495
6.	Secondary Steam (for de-aeration) Inlet Press (Bar)	3.99
7.	Secondary Steam Temperature °C	190.6
8.	Vacuum (Bar)	0.091
9.	Generator rating	132 MVA @ 50 C Cold Air Temp

10.	Unit Transformer rating	135 MVA
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STG-10 has undergone installation of modified 1st stage moving blades for load improvement and new LP turbine erosion protection rings of last 3 stages.

Heat Recovery steam generators HRSG-2 and HRSG-4 of Balke Durr Germany are in operation since COD 1991 without any major problems. Below is the design data for HRSG-2 and HRSG-4, both can be operated near to rated tonnage capacity and design parameters.

Table 4.13: Design Data of HRSG-2 and 4

HRSG-2: Balke Durr	
Steam Flow	208 t/h
Design Pressure	62 bar(g)
Super heater Outlet Pressure	47.1 bar(g)
Superheated Steam temperature	505°C
Total Heating Surface	58180 m ²
HRSG-4: Balke Durr	
Steam Flow	180.8 t/h
Design Pressure	62 bar(g)
super heater Outlet Pressure	48 bar(g)
Superheated Steam temperature	500°C
Total Heating Surface	54182 m ²

4.2.3. Current Operating Data of Module-2 Units:

Following data of Annual Dependable Capacity Test performed on dated 04-07-2020 shows that Module-2 units are operating near to or better than IDC parameters (IDC Initial dependable Capacity Test 1996) owing to prudent operating procedures and excellent maintenance strategy;

Table 4.14: Operating Data of Module-2

Gas Turbine No. 2: 42°C IDC & 34°C ADC ambient temperature on LSHO							
Reading	Real Load	Reactive Load	CDP	CDT	OTC	Inlet Loss	Exhaust Loss
	MW	MVAR	bar	°C	°C	Pascal	mbar
ADC-2020	94	26	8	342	488	400	21
IDC-1996	92	22	8.4	350	488	700	20.0
Gas Turbine No. 4: 42°C IDC & 34°C ADC ambient temperature, ADC on Gas & IDC on HSD fuel							
Reading	Real Load	Reactive Load	CDP	CDT	TET	Inlet Loss	Exhaust Loss
	MW	MVAR	bar	°C	°C	mm of H ₂ O	mbar

ADC-2020	77	26	10	395	582	113	17	
IDC-1996	74	9	10	404	577	64	15	
	Steam Turbine No. 10							
Reading	Real Load	Reactive	HP Inlet	HP Inlet	Ex Press	CW Inlet	Cooling Tower Fans	
	MW	MVAR	Press bar	Temp °C	bar	Temp °C	in service	
ADC-2020	98	15	41	490	0.11	34	6	
IDC-1996	94	13	43	456	0.18	34	6	
	HRSG-2		HRSG-4					
Reading	HP Steam	HP Steam	FW Inlet	Flue Gas	HP Steam	HP Steam	FW Inlet	Flue Gas
	Press bar	Temp °C	Temp °C	Temp °C	Press bar	Temp °C	Temp °C	Temp °C
ADC-2020	42	492	122	165	42	497	123	157
IDC-1996	44	499	125	190	40	500	122	160

4.2.4. Operating Record of Module-2 Units

Following data shows the operating hours, No. of starts, trips of the Module-2 Units since commissioning till 31 March 2021.

No. of starts are higher for GT-4 in regard to its total Operating hours <100,000.

Table 4.15: Operating Record of Module-2

Module-2 Operating Record since Commissioning till March 2021			
	GT-2	GT-4	STG-10
Date of commissioning	14-Jan-87	02-May-87	08-March-91
Total No. of Starts	4315	4987	2905
Operating Hours (OH)	162106	93756	157017
No. of Trips	218	87	188

4.2.5. Maintenance Record and History of Module-2 Units

Module-2 units are operated at base-load, within the original equipment manufacturer (OEM) guidelines. Following periodic maintenance tasks are performed:

Gas turbines:

- Combustion inspection

- Hot gas path inspection (Not needed for GT-2 as per OEM recommendation)
- Major Overhauling

Generators:

- Schedule inspection every year
- Major inspection after every 60000 EOH

Steam turbine:

- Minor Overhauling/Inspection/Borescope examination
- Major Overhauling

Table 4.16: Operating Record of Module-2

Activity	Data Items	GT-2	GT-4	SG-10
Combustion Inspection	Last CI Inspection Dates	10-Feb-21 To 16-Feb-21	21-Sep-19 To 27-Sep-19	-
Hot gas path inspection/Minor overhauling	Last HGPI Dates	- -	14-Sep-17 To 09-Nov-17	15-Feb-16 To 29-Mar-16
Major Over hauling	Last MOH Dates	01-Feb-18 To 26-Mar-18	15-Feb-16 To 29-Mar-16	01-Sep-13 To 29-Oct-13

4.2.6. Operating Performance of Module-2

Below is the past five years operating performance of Module-2 Units which shows that the Units are operating with best performance in comparison to IDC values and with high availability factor.

Average plant availability factor of above 85% and Commercial availability of above 95% is comparable to new plants in the power market.

Table 4.17: Operating Performance of Module-2

Gas Turbine GT-2		
Year	Plant Availability %	Commercial Availability %
2015-16	79	95
2016-17	93	98
2017-18	78	98
2018-19	80	97
2019-20	92	96
Average	86	97
Gas Turbine GT-4		
Year	Plant Availability %	Commercial Availability %
2015-16	84	97
2016-17	93	95
2017-18	79	97
2018-19	94	97
2019-20	93	99
Average	89	97
Steam Turbine STG-10		
Year	Plant Availability %	Commercial Availability %
2015-16	81	95
2016-17	93	96
2017-18	79	97
2018-19	87	97
2019-20	92	97
Average	88	97

4.2.7. Qualitative Conditional Assessment of Module-2 Units

Following is the qualitative conditional assessment of Module-2 Units;

Table 4.18: Qualitative Conditional Assessment

Unit #	Operating Parameters Maintained per IDC	Schedule Maintenance Performed	Upgraded	Upgrade Type	Spares Inventory Maintained	Overall Condition Rating	Overall Unit Condition
GT-2	Yes	Yes	Yes	-IGVs Modulating - Control Change	Yes	7	Satisfactory
GT-4	Yes	Yes	Yes	New Data Acquisition System	Yes	6	Acceptable
STG-10	Yes	Yes	Yes	Improved 1st stage moving blades	Yes	8	Satisfactory
HRS-2	Yes	Yes	No	NA	Yes	9	Good
HRS-4	Yes	Yes	No	NA	Yes	9	Good
Condition Rating Criteria 1-10: Rating 9-10 = Good; Rating 7-8 = Satisfactory; Rating 4-6 = Acceptable; Rating 1-3 = Unacceptable							

Keeping in view the Module-1 and 2 performance in preceding years, current operating conditions and upgrades performed on the Units it is envisaged that if current O&M practices are continued, Module-1 and 2 units can be further operated for a minimum further 10 years with good performance and high plant availability.

4.3. Overview of KAPCO Module-3

KAPCO Module-3 consists of Gas turbines GT-5 and GT-6, heat recovery steam generators HRSG-11A and HRSG-11B and steam turbine STG-11. Gas turbines GT-5 and GT-6 are of GE MS9001E type and were commissioned in Nov and Dec 1988 respectively in open cycle mode on HSD fuel.

GT-5 was commissioned on Furnace oil and Gas in May 1989 and May 1995 respectively. GT-6 was commissioned on Furnace oil and Gas in Jul 1989 and May 1995 respectively.

Module-3 open cycle gas turbines GT-5 and GT-6 were converted to combined cycle mode after commissioning of HRSG-11A and HRSG-11B along with steam turbine STG-11 in 1995.

Module-3 configuration is as follows: GT-5 + HRSG-11A, GT-6 + HRSG-11B and STG-11

4.3.1. Design and Current Operating conditions of Module-3 Units:

4.3.2. Design Data and Technical Limits of Module-3 Units

Gas Turbines GT-5 and 6 have operated satisfactorily since their commissioning in 1989 with periodic replacements of hot gas path components as per OEM recommended maintenance cycle. Below is the design data of GT-5 and GT-6 which is valid for current units operation;

Table 4.19: Design Data GT-5 and GT-6

Sr. No.	Description	GT-5 & GT-6
1.	Model	PG-9141 Type 9001 E
2.	Manufacturer	M/S ALSTHOM France.
3.	Base Load Rating at 15 °C	106 MW on HSD & 94.65 on FO
4.	Starting time up to 3000 RPM	10 Minutes
5.	Turbine Inlet Temp	1085°C on HSD & 1029°C on FO
6.	Turbine Exhaust Temp at full load	528°C on HSD & 489°C on FO
7.	Auto loading gradient	8 MW/minute
8.	Overall Efficiency	31.5 %

GT-5 and GT-6 Control systems have been replaced from the old GE Mark-IV to GE Mark-VIe in 2015 to enhance unit reliability.

GT-5 and GT-6 Hot Gas path up-gradation was carried out in 2011 which enhanced the load capacity of the Units.

Steam Turbine STG-11 is of RATEAU, France and has operated satisfactorily since its commissioning in 1995. Below is the design data of steam turbine Unit-11 which is valid for current unit operation;

Table 4.20: Design Data STG-11

Design Data		Unit: STG-11
1.	Make	RATEAU, France
2.	Type	VEGA209 110B
3.	Rated Power	103.4 MW
4.	Live Steam (for steam turbine) Inlet Press (Bar)	40
5.	Live Steam Temperature °C	510.8
6.	Secondary Steam (for de-aeration) Inlet Press (Bar)	-
7.	Secondary Steam Temperature °C	-
8.	Vacuum (Bar)	0.091
9.	Generator rating	121.647 MVA @ 36 C Cold Air Temperature
10.	Unit Transformer rating	125 MVA

Heat recovery steam generators HRSG-11A and 11B of Stein Industries France have operated since COD 1995 without any major problems. Below is the design data for HRSG-11A and 11B, both can be operated near to rated tonnage capacity and design parameters.

Table 4.21: Design Data HRSG-11A and B

Design Data	
Rated Steam Flow	151 T/H on LSFO & 173 T/H on Gas
Design Pressure	51 bar(g)
Superheater Outlet Pressure	35.8 bar(g) on LSFO & 42 bar(g) on Gas
Superheated Steam temperature	476°C on LSFO & 512°C on Gas
Total Heating Surface	56386 m ²

4.3.3. Current Operating Data of Module-3

Following data of Annual Dependable Capacity Test performed on 06-07-2020 shows that Module-3 units are operating near to or better than IDC parameters (Initial dependable Capacity Test 1996) at corrected ambient conditions owing to units up-gradations, KAPCO prudent operating practices and excellent maintenance strategy;

Table 4.22: Operating Data of Module-3

Gas Turbine No. 5 at 39°C ADC & 37°C IDC ambient temperature; on LSFO								
Reading	Real Load	Reactive Load	CDP	CDT	TET	Inlet Loss	Exhaust Loss	
	MW	MVAR	bar	°C	°C	Pascal	mmWC	
ADC-2020	72.0	14.0	9.20	358	500	603	140.0	
IDC-1996	74.0	10	9	-	507	130	69	
Gas Turbine No. 6 at 39°C ADC & 37°C IDC ambient temperature; on LSFO								
Reading	Real Load	Reactive Load	CDP	CDT	TET	Inlet Loss	Exhaust Loss	
	MW	MVAR	bar	°C	°C	Pascal	mmWC	
ADC-2020	72.0	20.0	9.10	360	504.0	474	140.0	
IDC-1996	76.0	11	9	-	506	176	64	
Steam Turbine No. 11								
Reading	Real Load	Reactive	HP Inlet	HP Inlet	Ex Press	CW Inlet	Cooling Tower Fans	
	MW	MVAR	Press bar	Temp °C	bar(g)	Temp °C	in service	
ADC-2020	76	13	32	411	-0.89	39	6	
IDC-1996	76	9	33	467	-0.88	39	6	
HRSG-11A				HRSG-11B				
Reading	HP Steam	HP Steam	FW Inlet	Flue Gas	HP Steam	HP Steam	FW Inlet	Flue Gas
	Press bar	Temp °C	Temp °C	Temp °C	Press bar	Temp °C	Temp °C	Temp °C
ADC-2020	33	473	140	158	32	484	140	159
IDC-1996	34	472	141	165	34	469	142	163

4.3.4. Operating Record of Module-3 Units

Following data shows operating hours, No. of starts, trips of Module-3 units since commissioning till 31 March 2021.

Table 4.23: Operating Record of Module-3

Module-3 Operating Record since Commissioning to March 2021			
	GT-5	GT-6	STG-11
Date of commissioning	14-Nov-88	29-Dec-88	04-Mar-95
Total No. of Eq Starts	4,240	4,413	2761
Operating Hours (OH)	144150	152072	128560
No. of Trips	201	179	239

4.3.5. Maintenance Record and History of Module-3 Units

Module-3 units are operated at base-load, within the original equipment manufacturer (OEM) guidelines. As per OEM recommendations, following periodic maintenance tasks are performed:

Gas turbines:

- Combustion inspection
- Hot gas path inspection
- Major Overhauling

Generators:

- Minor inspection after every 15000 Generator EOH
- Major Overhaul after every 46000 Generator EOH

Steam turbine:

- Minor Overhauling/Inspection/Borescope examination
- Major Overhauling

Table 4.24: Maintenance Record of Module-3

Activity	Data Items	GT-5	GT-6	STG-11
Combustion Inspection	Last CI Inspection Dates	01-Mar-21 To 05-Mar-21	01-Mar-21 To 05-Mar-21	-
Hot Gas Path Inspection/Minor Overhauling	Last HGPI Dates	11-Sep-17 To 30-Oct-17	11-Sep-17 To 30-Oct-17	01-Feb-20 To 31-Mar-20
Major Over Hauling	Last MOH Dates	16-Oct-11 To 03-Dec-11	16-Oct-11 To 03-Dec-11	11-Sep-17 To 30-Oct-17

4.3.6. Operating Performance of Module-3

Below is the past five years Plant Availability performance of Module-3 units which shows that Module-3 units are operating with best commercial performance with high availability factor.

Table 4.25: Maintenance Record of Module-3

Gas Turbine GT-5		
Year	Plant Availability %	Commercial Availability %
2015-16	82.8	97.8
2016-17	92.7	97.6
2017-18	80.8	95.8
2018-19	95.3	94.8
2019-20	94.0	97.0
Average	87.0	95.0
Gas Turbine GT-6		
Year	Plant Availability %	Commercial Availability %
2015-16	82	98
2016-17	82	88
2017-18	80	95
2018-19	95	92
2019-20	92	96
Average	84	92
Steam Turbine ST-11		
Year	Plant Availability %	Commercial Availability %
2015-16	82	97
2016-17	87	92
2017-18	80	95
2018-19	95	93
2019-20	93	96
Average	83	91

4.3.7. Qualitative Conditional Assessment of Module-3 Units

Following is the qualitative conditional assessment of Module-3 Units;

Table 4.26: Qualitative Conditional Assessment

Unit #	Operating Parameters Maintained per IDC	Schedule Maintenance Performed	Upgraded	Upgrade Type	Spares Inventory Maintained	Overall Condition Rating	Overall Unit Condition
GT-5	Yes	Yes	Yes	-Hot Gas Path Upgrade - Control System Change	Yes	8	Satisfactory
GT-6	Yes	Yes	Yes	-Hot Gas Path Upgrade - Control System Change	Yes	8	Satisfactory
STG-11	Yes	Yes	Yes	-Generator Rewind - Control System Change	Yes	8	Satisfactory
HRS-11A	Yes	Yes	No	NA	Yes	9	Good
HRS-11B	Yes	Yes	No	NA	Yes	9	Good
Condition Rating Criteria 1-10: Rating 9-10 = Good; Rating 7-8 = Satisfactory; Rating 4-6 = Acceptable; Rating 1-3 = Unacceptable							

4.4. Overview of KAPCO Module-4

KAPCO Module-4 consists of Gas turbines GT-7 and GT-8, heat recovery steam generators HRSG-12A and HRSG-12B and steam turbine STG-12. Gas turbines GT-7 and GT-8 of GE MS9001E type were commissioned in Jan and April 1989 respectively in open cycle mode on HSD fuel.

GT-7 was commissioned on Furnace oil and Gas in Aug 1989 and May 1995 respectively. GT-8 was commissioned on Furnace oil and Gas in Sep 1989 and May 1995 respectively.

Module-4 open cycle gas turbines GT-7 and GT-8 were converted to combined cycle mode after commissioning of HRSGs; HRSG-12A and 12B along with steam turbine STG-12 in April 1995.

Module-4 configuration is as follows: GT-7 + HRSG-12A, GT-8 + HRSG-12B and STG-12

4.4.1. Design and Current Operating conditions of Module-4 Units:

4.4.2. Design Data and Technical Limits of Module-4 Units

Gas Turbines GT-7 and 8 are in operation satisfactorily since their commissioning with periodic replacements of hot gas path components as per OEM recommended maintenance cycle. Below is the design data of GT-7 and GT-8 which is valid for current units operation;

Table 4.27: Design Data GT-7 and GT-8

Sr. No.	Description	GT-7 & GT-8
1.	Model	PG-9141 Type 9001 E
2.	Manufacturer	ALSTHOM France.
3.	Base Load Rating at 15°C	106 MW on HSD & 94.65 on FO
4.	Starting time up to 3000 RPM	10 Minutes
5.	Turbine Inlet Temp	1085°C on HSD & 1029°C on FO
6.	Turbine Exhaust Temp at full load	528°C on HSD & 489°C on FO
7.	Auto loading gradient	8 MW/minute
8.	Overall Efficiency	31.5 %

GT-7 and GT-8 Control system is the old GE Mark-IV which is operating reliably with availability of additional spares obtained from replacement of GT-5 and GT-6 control system.

GT-7 and GT-8 Hot Gas path up-gradation were carried out in 2011 and 2010 respectively which enhanced the load capacity of the units.

Steam Turbine STG-12 is of RATEAU, France and has operated satisfactorily since its commissioning in 1995. Below is the design data of steam turbine Unit-12 which is valid for current unit operation;

Table 4.28: Design Data of STG-12

Sr. No.	Description	Unit: STG-12
1.	Make	RATEAU, France
2.	Type	VEGA209 110B
3.	Rated Power	103.4 MW
4.	Live Steam (for steam turbine) Inlet Press (Bar)	40
5.	Live Steam Temperature °C	510.8
6.	Secondary Steam (for de-aeration) Inlet Press (Bar)	-
7.	Secondary Steam Temperature °C	-
8.	Vacuum (Bar)	0.091
9.	Generator rating	121.647 MVA @ 36°C Cold Air Temperature
10.	Unit Transformer rating	125 MVA

Heat recovery steam generators HRSG-12A and 12B of Stein Industries France have operated since COD 1995 without any major problems. Below is the design data for HRSG-12A and 12B, both can be operated near to rated tonnage capacity and design parameters.

Table 4.29: Design Data of HRSG-12A and B

HRSG-12A & B: Stein Industries France	
Rated Steam Flow	151 T/H on LSFO & 173 T/H on Gas
Design Pressure	51 bar(g)
Superheater Outlet Pressure	35.8 bar(g) on LSFO & 42 bar(g) on Gas
Superheated Steam temperature	476°C on LSFO & 512°C on Gas
Total Heating Surface	56386 m ²

4.4.3. Current Operating Data of Module-4 Units

Following data of Annual Dependable Capacity Test performed on 06-07-2020 depicts that Module-4 units are operating near to or better than IDC parameters (IDC Initial dependable Capacity Test 1996) owing to the Units up-gradations, KAPCO prudent operating practices and excellent maintenance strategy;

Table A.30: Operating Data of Module-4

Gas Turbine No. 7 at 32°C ADC & 32.5°C IDC ambient temperature on LS O								
Reading	Real Load	Reactive Load	CDP	CDT	TET	Inlet Loss	Exhaust Loss	
	MW	MVAR	bar	°C	°C	Pascal	mmWC	
ADC-2020	81	10	9	349	499	573	155	
IDC-1996	79	10	9	-	505	-	25	
Gas Turbine No. 8 at 32°C ADC & 32.5°C IDC ambient temperature on LS O								
Reading	Real Load	Reactive Load	CDP	CDT	TET	Inlet Loss	Exhaust Loss	
	MW	MVAR	bar	°C	°C	Pascal	mmWC	
ADC-2020	80	14	9	351	501	621	156	
IDC-1996	82	10	9	350	502	-	26	
Steam Turbine No. 12								
Reading	Real Load	Reactive	HP Inlet	HP Inlet	Ex Press	CW Inlet	Cooling Tower Fans	
	MW	MVAR	Press bar	Temp °C	bar(g)	Temp °C	in service	
ADC-2020	78	9	34	465	-0.891	35	6	
IDC-1996	81	12	33	476	-0.896	34	6	
HRSG-12A				HRSG-12B				
Reading	HP Steam	HP Steam	FW Inlet	Flue Gas	HP Steam	HP Steam	FW Inlet	Flue Gas
	Press bar	Temp °C	Temp °C	Temp °C	Press bar	Temp °C	Temp °C	Temp °C
ADC-2020	35	460	142	162	35	471	142	162
IDC-1996	34	480	143	163	33	480	143	163

4.4.4. Operating Record of Module-4 Units

Following data shows operating hours, No. of starts, trips of Module-4 units since commissioning till 31 March 2021.

Table 4.31: Operating Record of Module-4

Module-4 Operating Record since Commissioning to March 2021			
	GT-7	GT-8	STG-12
Date of commissioning	19-Jan-89	24-Apr-89	05-Apr-95
Total No. of Eq Starts*	1710	3635	2735
Operating Hours (OH)	152405	157488	139812
No. of Trips	161	226	257

4.4.5. Maintenance Record and History of Module-4 Units

Module-4 units are operated at base-load, within the original equipment manufacturer (OEM) guidelines. As per OEM recommendations, following periodic maintenance tasks are performed:

Gas turbines:

- Combustion inspection (CI)
- Hot gas path inspection (HGPI)
- Major Overhauling (MOH)

Generators:

- Minor inspection after every 15000 Generator EOH
- Major Overhaul after every 46000 Generator EOH

Steam turbine:

- Minor Overhauling/Inspection/Borescope examination
- Major Overhauling

Table 4.32: Maintenance Record of Module-4

Activity	Data Items	GT-7	GT-8	STG-12
Combustion Inspection	Last CI Inspection Dates	01-Feb-21 To 22-March-21	11-Feb-21 To 02-Mar-21	-
Hot gas path inspection/Minor Overhauling	Last HGPI Dates	01-Feb-21 To 22-March-21	01-Feb-19 To 28-Feb-19	11-Feb-21 To 02-Mar-21
Major Over hauling	Last MOH Dates	01-Feb-21 To 22-March-21	01-Feb-19 To 28-Feb-19	11-Feb-15 To 24-Mar-15

GT-5, 6, 7 and 8 CI, HGPI and MOH, all maintenance tasks are executed by KAPCO team. Spare parts used for the GTs and STGs routine maintenance are supplied by the respective OEMs GE/Alstom.

4.4.6. Operating Performance of Module-4

Below is the past five years Commercial performance of Module-4 units which shows that Module-4 units are operating with best commercial performance with high availability factor.

Table 4.33: Operating Performance of Module-4

Gas Turbine GT-7		
Year	Plant Availability %	Commercial Availability %
2015-16	84	92
2016-17	81	97
2017-18	92	97
2018-19	93	97
2019-20	94	97
Average	88	96
Gas Turbine GT-8		
Year	Plant Availability %	Commercial Availability %
2015-16	77	87
2016-17	80	97
2017-18	90	94
2018-19	91	93
2019-20	87	97
Average	83	94
Steam Turbine STG-12		
Year	Plant Availability %	Commercial Availability %
2015-16	78	87
2016-17	80	97
2017-18	90	95
2018-19	91	95
2019-20	90	97
Average	85	95

4.4.7. Qualitative Conditional Assessment of Module-4 Units

Following is the qualitative conditional assessment of Module-4 Units;

Table 4.34: Qualitative Conditional Assessment

Unit #	Operating Parameters Maintained per IDC	Schedule Maintenance Performed	Upgraded	Upgrade Type	Spares Inventory Maintained	Overall Condition Rating	Overall Unit Condition
GT-7	Yes	Yes	Yes	-Hot Gas Path Upgrade -Rotor Replaced with new	Yes	7	Satisfactory
GT-8	Yes	Yes	Yes	-Hot Gas Path Upgrade -Rotor Refurbished -Generator Stator rewind	Yes	8	Satisfactory
STG-12	Yes	Yes	Yes	-Generator Stator rewind - Control System Change	Yes	9	Good
HRSG-12A	Yes	Yes	No	NA	Yes	9	Good
HRSG-12B	Yes	Yes	No	NA	Yes	9	Good
Condition Rating Criteria 1-10: Rating 9-10 = Good; Rating 7-8 = Satisfactory; Rating 4-6 = Acceptable; Rating 1-3 = Unacceptable							

Keeping in view the Module-3 and 4 performance in preceding years, current operating conditions and upgrades performed on units it is envisaged that if current O&M practices are continued, Module-3 and 4 units can be further operated for a minimum further 10 years with good performance figures and high plant availability.

4.5. Overview of KAPCO Module-5

KAPCO Module-5 consists of Gas turbines GT-13 and GT-14, heat recovery steam generators HRSG-13 and HRSG-14 and steam turbine STG-15. Gas turbines GT-13 and GT-14 of Siemens V94.2 were commissioned in Oct 1994 in open cycle mode on Gas fuel and are the newest of all the Gas Turbines in the KAPCO Complex.

GT-13 was commissioned on liquid fuel HSD and Furnace oil in April and May 1995 respectively.

GT-14 was commissioned on liquid fuel HSD and Furnace oil in March and April 1995 respectively.

Module-5 open cycle gas turbines GT-13 and GT-14 were converted to combined cycle mode after commissioning of HRSG-13 and HRSG-14 along with steam turbine STG-15 in Sep 1996.

Module-5 configuration is as follows: GT-13 + HRSG-13, GT-14 + HRSG-14 and STG-15

4.5.1. Design and Current Operating conditions of Module-5

4.5.2. Design Data and Technical Limits of Module-5 Units

Gas Turbines GT-13 and 14 have operated satisfactorily since their commissioning with periodic replacements of hot gas path components as per OEM recommended maintenance cycle. Below is the design data of GT-13 and GT-14;

Table 4.35: Design Data of GT-13 and GT-14

Sr. No.	Description	GT-13 & GT-14
1.	Model	V-94.2
2.	Manufacturer	SIEMENS (Germany)
3.	Base Load rating at 15°C	139 MW (HSD), 143.8 MW (GAS), 123 MW (F.O)
4.	Starting time up to 3000 RPM.	4 Minutes
5.	Turbine Inlet Temp	1050°C
6.	Turbine Exhaust	530 to 550°C Temp at full load
7.	Auto loading gradient	i) 11 MW/Minute up to base load
8.	Overall Efficiency	(32 % on BFO), (32% on HSD), (32.5% on GAS)

*Turbine Inlet and exhaust temperature values has been revised around 5°C after Si3D upgrade

GT-13 and GT-14 old Control system Siemens TELEPERM ME has been replaced with a new Control system SPPAT3000 in Feb-March 2021.

GT-13 and GT-14 Si3D turbine blades up-gradation was carried out in 2011 which enhanced the load capacity

Steam Turbine STG-15 is of Siemens, Germany and has operated satisfactorily since its commissioning in 1995. It is a 2 cylinder turbine with HP and LP portions and a water cooled condenser.

Below is the design data of steam turbine Unit-15 which is valid for current unit operation;

Table 4.36: Design Data of STG-15

Sr.No.	Description	Unit STG-15
1.	Make	Siemens, Germany
2.	Type:	030-16, N30-2X5-B-9
3.	Rated Power	148.6 MW
4.	Live Steam (for steam turbine) Inlet Press (Bar)	57
5.	Live Steam Temperature °C	528
6.	Secondary Steam (for de-aeration) Inlet Press (Bar)	5.78
7.	Secondary Steam Temperature °C	221
8.	Vacuum (Bar)	0.091
9.	Generator rating	175 MVA @ 40°C Cold Air Temperature
10.	Unit Transformer rating	190 MVA

STG-15 Control system has been replaced from the old Siemens TELEPERM ME to a new SPPAT3000 in 2015.

Heat Recovery steam generators HRSG-13 and 14 of Babcock Germany have operated since COD 1995. HRSG-13 and 14 LP Evaporator bends were replaced in 2013 and 2016 due to frequent leakages as a consequence of flow accelerated corrosion. HRSG-13 and 14 are now operating satisfactorily without any major problem. Below is the design data for HRSG-13 and 14, both are operating at rated tonnage capacity and design parameters.

Table 4.37: Design Data of HRSG-13 and 14

HRSG-13 & 14, Babcock Germany	
Year of Manufacture	1995
Rated Steam Flow	64 Kg/sec
Design Pressure	75 bar(g)
Super-heater Outlet Pressure	59 bar(g)
Superheated Steam temperature	530°C
Total Heating Surface area	84094 m ²

4.5.3. Current Operating Data of Module-5 Units

Following data of Annual Dependable Capacity Test performed on dated 03-07-2020 depicts that Module-5 units are operating near to or better than IDC parameters corrected to same ambient conditions (IDC Initial dependable Capacity Test Aug 1997) owing to units up-gradations, KAPCO prudent operating practices and excellent maintenance strategy;

Table 4.38: Operating Data of Module-5

Gas Turbine No. 13 at 31°C ADC & 37°C IDC ambient temperature, on LSFO								
Reading	Real Load	Reactive Load	CDP	CDT	OTC	Inlet Loss	Exhaust Loss	
	MW	MVAR	bar	°C	°C	mbar	mbar	
ADC-2020	115	25	9	347	506	0.96	23	
IDC-1997	105	28	9	353	505	5	21	
Gas Turbine No. 14 at 31°C ADC & 37°C IDC ambient temperature, on LSFO								
Reading	Real Load	Reactive Load	CDP	CDT	OTC	Inlet Loss	Exhaust Loss	
	MW	MVAR	bar	°C	°C	mbar	mmWC	
ADC-2020	112	25	9	345	503	1.3	18	
IDC-1997	106	19	9	352	504	6	21	
Steam Turbine No. 15								
Reading	Real Load	Reactive	HP Inlet	HP Inlet	Ex Press	CW Inlet	Cooling Tower Fans	
	MW	MVAR	Press bar	Temp °C	bar(g)	Temp °C	in service	
ADC-2020	115	28	47	502	-0.88	34	6	
IDC-1997	113	33	47	484	-0.88	34	6	
HRSG-13				HRSG-14				
Reading	HP Steam	HP Steam	FW Inlet	Flue Gas	HP Steam	HP Steam	FW Inlet	Flue Gas
	Press bar	Temp °C	Temp °C	Temp °C	Press bar	Temp °C	Temp °C	Temp °C
ADC-2020	47	509	128	165	47	509	128	166
IDC-1997	48	494	147	180	47	488	147	182

4.5.4. Operating Record of Module-5 Units

Following data shows operating hours, No. of starts, trips of Module-5 units since commissioning till 31 March 2021.

Table 4.39: Operating Record of Module-5

Module-5 Operating Record since Commissioning to June 2019			
	GT-13	GT-14	STG-15
Date of commissioning	12-Oct-94	19-Oct-94	10-Sep-96
Total No. of Starts	2047	2260	657
Operating Hours (OH)	176245	170947	179741
No. of Trips	158	146	151

4.5.5. Maintenance Record and History of Module-5 Units

Module-5 units are operated at base-load, within the original equipment manufacturer (OEM) guidelines. Depending upon the Equivalent Operating hours of the Unit and OEM recommendations, following periodic maintenance tasks are performed:

Gas turbines:

- Combustion inspection (CI)
- Major Overhauling (MOH)

Generators:

- Schedule inspection every year
- Major inspection after every 60,000 EOH (Condition based)

Steam turbine:

- Minor Overhauling/Inspection/Borescope examination
- Major Overhauling

GT-13 and GT-14 Combustion inspection is executed by the KAPCO team while the MOH is executed by Siemens' Engineers. As per the maintenance life cycle, all spare parts used for replacement, are supplied by the OEM, Siemens, in accordance with the LTSA (Long Term Supply Agreement). Due to excellent maintenance workmanship and genuine spare parts usage, units are operating smoothly with high availability factor. Below is the overview for the Outages performed as per OEM recommended interval;

Table 4.40: Maintenance Record of Module-5

Activity	Data Items	GT-13	GT-14	STG-15
Combustion Inspection	Last CI Inspection Dates	16-Nov-20 To 20-Nov-20	16-Nov-20 To 20-Nov-20	-

Hot gas path inspection/Minor Overhauling	Last HGP! Dates	-	-	01-Sep-16 To 04-Nov-16
Major Overhauling	Last MOH Dates	01-Sep-19 To 30-Oct-19	01-Sep-19 To 30-Oct-19	01-Feb-10 To 25-Apr-10

4.5.6. Operating Performance of Module-5

Below is the past five years operating performance of Module-5 units which shows that Module-5 units are operating with best commercial performance figures and with high availability factor. Average plant availability factor of 86% and Commercial availability of above 95% is comparable to new plants in the power market.

Table 4.41: Operating Performance of Module-5

Gas Turbine GT-15		
Year	Plant Availability %	Commercial Availability %
2015-16	92	98
2016-17	76	99
2017-18	92	98
2018-19	91	96
2019-20	78*	96
Average	86	97
Gas Turbine GT-14		
Year	Plant Availability %	Commercial Availability %
2015-16	90	95
2016-17	77	96
2017-18	91	98
2018-19	94	95
2019-20	80	97
Average	86	96
Steam Turbine STG-15		
Year	Plant Availability %	Commercial Availability %
2015-16	90	96
2016-17	73	97
2017-18	91	98
2018-19	92	95
2019-20	78	96
Average	84	96

*GT-13-14 & STG-15 Plant Availability FY 2016-17 & 2019-20 is less in comparison due to schedule MOH Oct-Nov 2016 & Sep-Oct 2019

4.5.7. Qualitative Conditional Assessment of Module-5 Units

Following is the qualitative conditional assessment of Module-5 Units;

Table 4.42: Qualitative Conditional Assessment of Module-5

Unit #	Operating Parameters Maintained per IDC	Schedule Maintenance Performed	Upgraded	Upgrade Type	Spares Inventory Maintained	Overall Condition Rating	Overall Unit Condition
GT-13	Yes	Yes	Yes	-Si3D Turbine Blades Upgrade - Control System Change	Yes	7	Satisfactory
GT-14	Yes	Yes	Yes	-Si3D Turbine Blades Upgrade - Control System Change	Yes	7	Satisfactory
STG-15	Yes	Yes	Yes	- Control System Change	Yes	9	Good
HRS-13	Yes	Yes	No	NA	Yes	9	Good
HRS-14	Yes	Yes	No	NA	Yes	9	Good
Condition Rating Criteria 1-10: Rating 9-10 = Good; Rating 7-8 = Satisfactory; Rating 4-6 = Acceptable; Rating 1-3 = Unacceptable							

Keeping in view the Module-5 performance in preceding years, current operating conditions and recent upgrades performed on the Units it is envisaged that if current O&M practices are continued, Module-5 units can be further operated for minimum further 10 years with good performance figures and high plant availability.

5. WORLD TRENDS IN OPERATING LIFE OF THERMAL POWER PLANTS

5.1. Definitions

In order to discuss how long a plant will operate for it is important to discuss the following widely used phrases.

5.1.1. Operating life

The operating life of a power station can be defined as the length of time in years after commissioning that a plant will generate, or has been generating electricity before being decommissioned.

5.1.2. Economic life

The economic life of a plant refers to a prediction of how long it will be generating based on specific economic criteria such as remaining profitable. The economic life is usually discussed within the context of a forecast of certain financial factors such as future electricity prices, fuel costs and investment required to extend the life of the plant. A plant reaching the end of its economic life suggests it would then be decommissioned, however there are situations where the plant may be retained in an operational state, a state of readiness to return to service, or mothballed.

5.1.3. Design life

The design life refers to the length of time used in engineering design and manufacture specifications for the plant. Design life is typically defined in terms of operating hours which are then translated into an expected calendar lifetime depending on the operating regime – base load, peaking etc. A plant could be designed to operate for 25-30 years in a specific operating regime which, for example, dictates the use of specific alloys or thickness of heat shielding equipment. A change in operating regime can affect the assets calendar lifetime.

5.1.4. Heat rate

When forecasting plant life, it is useful to consider impacts of time and operating regime on the heat rate or efficiency of the power station. Heat rate is usually measured as kJ/KWh, and indicates the amount of fuel energy (kJ) required to generate a unit of electricity (kWh). Therefore, the lower the heat rate the higher the efficiency of the plant.

Plant heat rate or efficiency will degrade over time with use due to the wearing of components. Routine maintenance and overhauls are designed to minimize the effects of degradation and maintain the heat rate as close to the original design criteria as possible over the life of the plant. Restoring the heat rate back to the original design or better, requires significant investment and often involves replacement of the majority of components with technically superior equivalents.

Plant heat rate can be one of the major factors influencing plant life, as efficiency ultimately impacts economic viability. If the heat rate has degraded to the extent that significant capital investment is required to restore the heat rate and the benefits of such investment do not provide a positive economic return, a decision can be made to decommission the plant.

5.2. Factors influencing the plant life

5.2.1. General

In most cases power plant can have its life extended by a factor of 50-100% over the original design life. This arises in part from the conservative assumptions made in the original design process and in part is a consequence of well-managed repair and maintenance in these plants. In addition, the civil works of a plant are generally designed with a longer design life than the equipment, which means it is possible to replace equipment without having to build new civil works.

These factors have resulted in many power plants the world over operating well beyond their nominal 25 – 30 year design life.

5.2.2. Life limiting factors

For an operating power plant, the main technological life limiting issues are:

- The creep life of high temperature components. This is typically limited to boiler pressure parts, high temperature pipework and the heavy wall thickness and/or non-symmetrical high pressure (HP) steam turbine components (e.g. emergency stop valves, bypass valves, governor valves, steam chests, HP cylinder casings, HP nozzle rings). It may include the HP turbine rotor, both shaft and disks. Fatigue life of rotating components, components subject to repeated temperature change, and components subject fluctuating loads and vibration.
- Erosion – primarily related to gas side solid particle erosion of the boiler pressure parts. However, water and steam side erosion can also be an issue, particularly in low pressure steam turbines.
- Corrosion
- Technological obsolescence – primarily an issue with controls and instrumentation and electrical systems.
- Environmental compliance – environmental consents are only granted for limited periods and emission compliance, particularly if the environment is subsequently degraded or regulations become more stringent, may require major emissions control equipment (e.g. Low NO_x Burners, flue gas desulfurization (FGD), carbon capture etc).

5.3. World trends of life of coal and gas power stations

5.3.1. USA

Coal-fired electricity generators accounted for 25% of operating electricity generating capacity in the United States and generated about 30% of U.S. electricity in 2016. Most coal-fired capacity (88%) was built between 1950 and 1990,

Approximately 70% of the existing USA coal fueled power plant fleet is greater than 30 years old, as shown in the below Figure 5.1. The capacity-weighted average age of operating coal facilities is 39 years.

U.S. utility-scale electric generating capacity by initial operating year (as of Dec 2016)

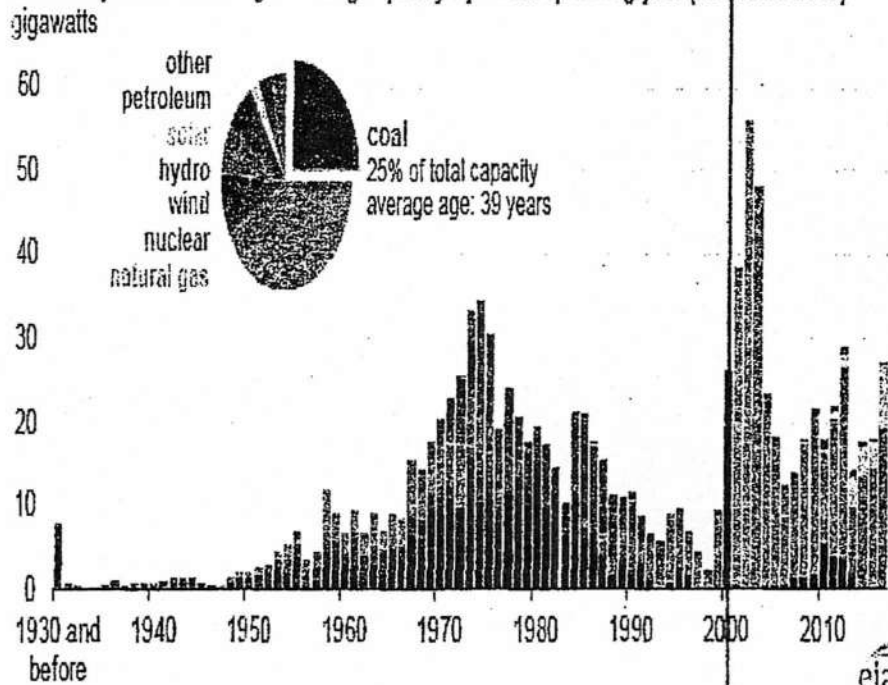


Figure 5. 1: US Power Generating Capacity

<https://www.eia.gov/todayinenergy/detail.php?id=30812>

5.3.2. Europe

European power plants are also maintained well beyond the original design life as shown in the below Figure 5.2;

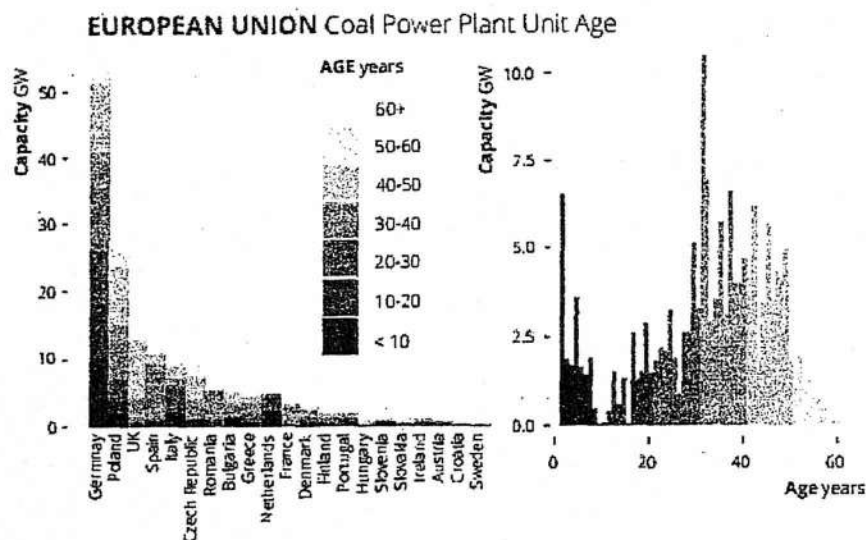


Figure 5. 2: European Union Coal Power Plant Unit age

Ref: A Stress Test for Coal in Europe Feb 2017

About capacity 25000 MW of thermal power plants are in age range 30 to 60 years that is exceeding their design life of 30 years.

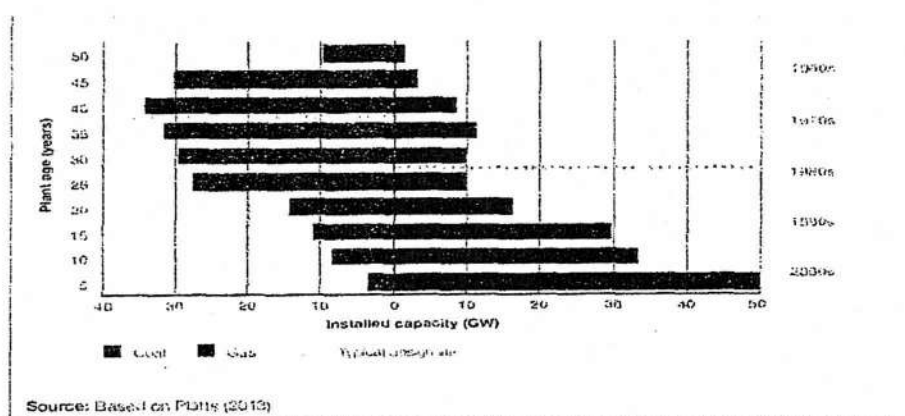
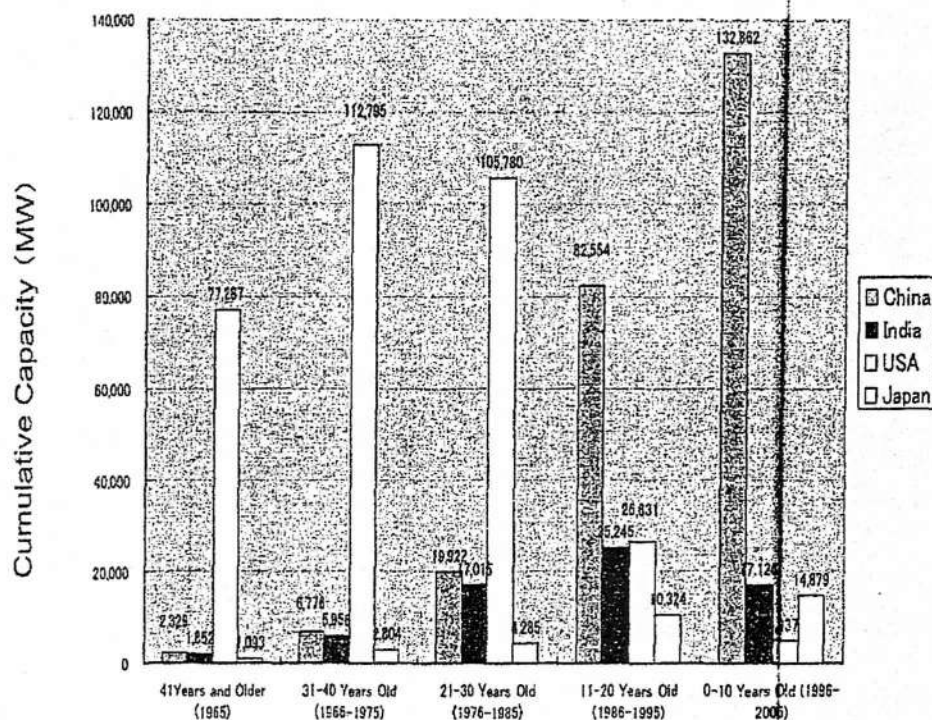


Figure 5. 3: European Power Plants' age by fuel

The trend in age of coal-fueled plants in Europe is similar to that in the USA. However, compared to the USA, where the gas-fueled power plants are relatively young, the European gas-fueled plants are on average older.

5.3.3. Other

Power plants in the developing countries of China and India are more recent compared to the ones in the USA, and most of them have not yet reached their nominal design life. This is illustrated by the following Figure (Age of power plants compared between countries) which compares the age of existing coal-fueled power plants in China, USA, India and Japan in 2007.



Sources: Pradeep J. Tharakan, USAID-ECO-Asia Clean Development and Climate Program, ASEAN Energy Business Forum (AEBF) 22nd-24th Aug., 2007 and Coal Note 2005/2006

Figure: 5. 4: Power Plants' age by Country

5.3.4. Power Project Age of Recent and Planned Retirements in US

The below charts present histograms of project age of recent and planned retirements for US coal plants, natural-gas steam (NGST) plants, combustion turbine (CT) plants, and combined-cycle gas turbine (CCGT) plants.

Several observations are apparent from these charts:

Recently retired plants have been relatively old, across all generation types

- The most common age of recently retired coal units is 50-60 years
- The most common age of recently retired NGST units is 40-50 years
- The most common age of recently retired CT units is 40-50 years
- The most common age of recently retired nuclear units is 30-40 years

Plants with announced retirement dates are also relatively old, based on expected age at retirement

- Nuclear and NGST plants planned for retirement will be older than recently retired plants
- Coal, CT and CCGT plants planned for retirement will be slightly younger than recently retired plants

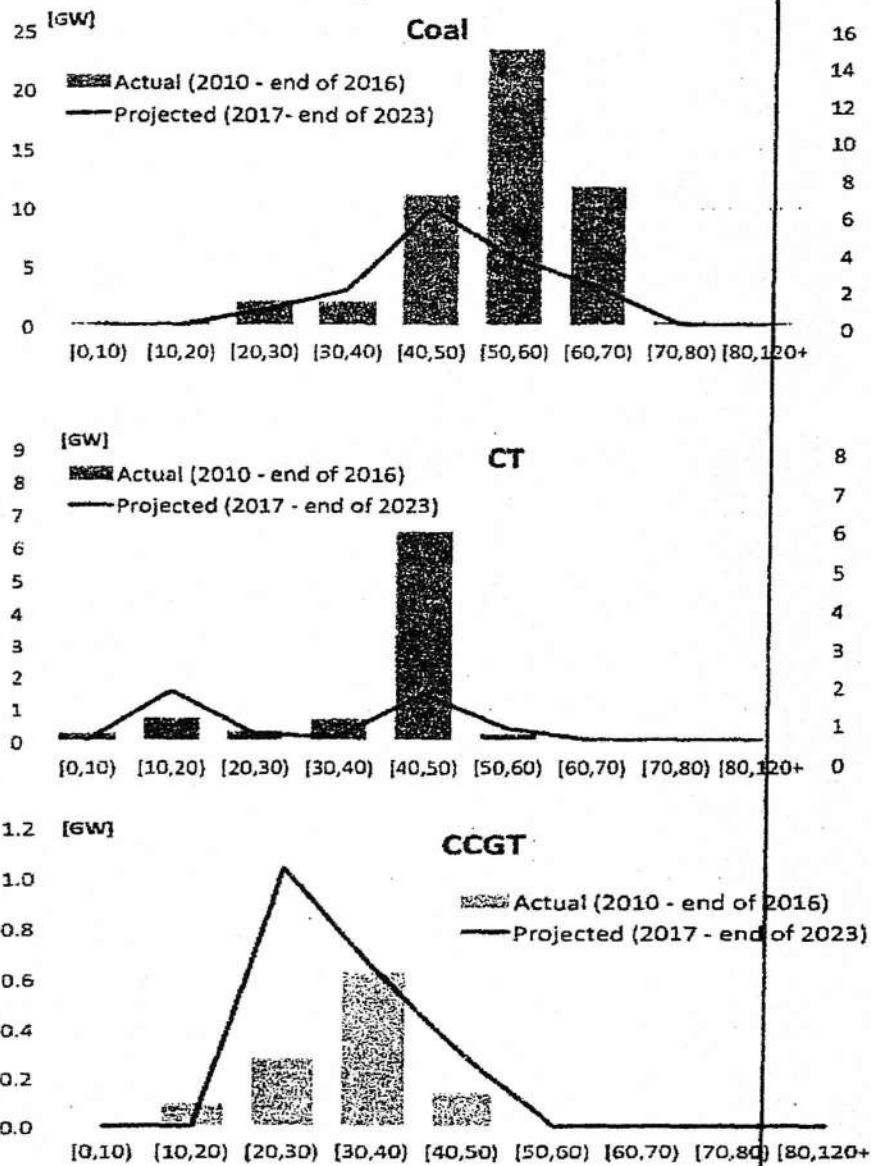


Figure 5. 5: Power Project Age of Recent and Planned Retirements in US

Ref: Energy Analysis and Environmental Impacts Division Lawrence Berkeley National Laboratory Nov 2017

5.4. Recap

As observed some coal fueled steam and natural gas turbines are 40-50 years old and still in operation 20 years beyond the original nominal calendar design life.

Traditionally, a calendar design life is equated to operating hours based on a nominal 8,000 per year to take account of scheduled and unscheduled outages and the fact that the plant will not usually operate 8,760 hours per year. Therefore a 30-year plant life equates to 240,000 operating hours.

Whilst the original design life of a CCGT plant is typically 25-30 years, the average life of retirement for CCGT plant is 40-50 years, or 320,000 hours based on 40 years and 8,000 operating hours per year.

Notwithstanding that plants can operate for an age of 40-50 years, the equipment operating design life usually means replacements and upgrades are required throughout that period and the frequency of maintenance generally increases as the plants ages.

Whether thermal power plants are kept in operation, refurbished, placed on standby or decommissioned at their design life remains primarily an economic decision for the owner depending upon the unit condition and maintenance cost. The introduction of more stringent Environmental regulations may also be a factor in whether it is cost effective to upgrade a plant to meet latest emissions criteria.

6. PLANT COMPONENTS RESIDUAL LIFE ASSESSMENT

6.1. Module-1 Plant Component Residual Life Assessment

6.1.1. Gas Turbine Unit 1, 3 and Steam Turbine Unit-9

GT-1 and 3 Hot gas path components are being replaced periodically on MOH/HGPI as per recommended intervals by OEM. One set of vanes and blades is available in store as a strategic spare.

Gas Turbine GT-1: Last Major Overhauling (MOH) was conducted in Feb-March 2021. The compressor blades have been in service since commissioning. During visual inspections and NDTs performed during the MOH, the condition of the compressor blades were found to be satisfactory. In the event some findings appear in the next MOH, replacement of the compressor blades is recommended.

Air intake system structure is in healthy condition. New air intake filters are available in the market.

Compressor Diaphragms stages 1-9 were replaced with refurbished and new diaphragms were installed for stages 10-16 in 2011. The condition of the compressor diaphragms was reported to be satisfactory in the MOH of 2021.

New mixing chambers were installed in March 2016 during the MOH and the expected remaining life is 15 years.

Gas Turbine GT-3: Overall condition of GT-3 was reported as satisfactory during visual inspections and NDTs performed in the MOH of 2016 and HGPI in 2018. One complete GT rotor is available for GT-3 and GT-4 as a strategic spare.

Steam Turbine STG-9 condition was found to be satisfactory during recent MOH Feb-March 2021. Mandatory spares are available in KAPCO Stores.

Following is the expected Remaining Life of Module-1 units as per current operating regime;

Table 6. 1: Remaining Life of Module-1 Units

Unit #	Operating Hours in Design Life of 30 years	Operating Hours in Extended Design Life of 40 years*	KAPCO Operating Hours COD to Mar-2021	Remaining Operating Hours In Extended Design Life of 40 years	Remaining Design life (Years)
GT-1	240,000	320,00	171,801	148,199	19
GT-3	240,000	320,00	93,920	226,080	28
STG-9	240,000	320,00	165,469	154,531	19

Module-1 Units are expected to operate for minimum further 10 years without any major concern.

*CCGT Operating Life expectancy before retirement is 40 years (320,000 hours based on 8,000 operating hours/year) ref section 5.3.4 and 5.4 of this document.

6.1.2. Module-1 HRSG 1 and 3

HRSG-1 to 4 are of same model and make of Balke.Durr, Germany. All four heat recovery steam generators have operated satisfactorily since their commissioning.

Life assessment of HRSG-1 was conducted by SGS Pakistan on sample basis among all four HRSGs of Block-1 (Module-1 and 2). The same condition about life assessment is predicted for the other three HRSGs i.e. HRSG-2, 3 and 4 as these HRSGs have fewer operating hours and have generally been operated and maintained the same.

HRSG-1 inspections relating to life assessment have been conducted during the recent major overhauling of STG-9 Feb- March 2021 and no significant deterioration observed.

(see Appendix-1: Remnant Life assessment of HRSG-1).

High pressure parts of HRSG 1, were inspected by SGS. The purpose of inspection was to evaluate the present conditions of high-pressure parts and assess their reliability for further use on the basis of their microstructure and wall-thickness.

Following inspection techniques were used for life assessment study of HRSG-1.

- Visual Inspections
- Ultrasonic Thickness Measurement
- Ultrasonic Flaw Detection
- Dye Penetrant Testing
- Magnetic Particle Inspection
- Hardness Testing
- Metallographic examination

Scope of work for complete inspection and remaining life assessment of HRSG 1 included following inspections and NDTs;

- Visual inspection of HP and LP drums, tubes, headers, for localized and uniform corrosion, deposits, erosion, pitting etc.
- Visual inspection of protective coating/insulation for damages
- Visual inspection for corrosion under insulation (CUI)
- Visual inspection of all structural steel parts including ducts, platforms, handrails and structural steel supports for ducts/piping for any visual defects.
- Visual inspection of tube bends and headers
- Visual inspection and DPT of steam header pipe welds for cracks
- Visual inspection of all accessible weld joints of HP Drum/LP separator, like shell, heads and nozzles.

- Hardness testing of HP drum, LP drum and headers.
- Ultrasonic flaw detection of suspected weld joints of HP drum, LP drum.
- MPI/DPT of selected weld joints
- Metallographic testing of boiler pressure parts.
- Ultrasonic thickness gauging of HP drum, headers, tubes, soot blowers, as per ASME codes to find out overall view of current metal condition for fitness.

Remaining Life of HRSG-1 was calculated, comparing component's thickness at installation and current thickness gauging 2021 using remaining corrosion allowance. All major components' life is calculated greater than 20 years.

Also, HRSG-1 and 3 mandatory inspections are carried out in every schedule outage of GT-1 and GT-3 by the Boiler Engineer, Mechanical Engineer and Plant Chemist.

Inspections were also performed in Feb 2021 and both HRSGs condition found satisfactory.

Based on life assessment reports, and routine maintenance inspections, it is expected that with the current operating regime, *HRSG-1 and 3 may be operated reliably for next 10-15 years.*

6.1.3. Module-1 Unit's Generator 1, 3 and 9

Following are the technical specifications for Module-1 and 2 Units' Generators

Table 6.2: technical specifications of Module-1 and 2 Generators

Technical Specifications	GT-1-2	GT-3-4	STG-9-10
Type:	TLRI 108/41	SGTIC 243704	WX 21L-064LL
Make:	KWU	ERCOLEMARELLI	ABB
Rated Out Put (MVA):	135	87	132
Power Factor:	0.85	0.85	0.85
Rated Voltage (KV):	10.5	11.0	11.0
Rated Current (A):	7423	4567	6928
Frequency (HZ):	50	50	50
Gen Cooling System	Air Cooled	Air Cooled	Air Cooled
Cold air temp	55°C	55°C	33.3°C

6.1.3.1. GT-1 Unit Generator

GT-1 Unit Generator of Siemens make has operated satisfactorily since its commissioning. Routine offload, on load, test results showed its healthy condition.

Unit-1 Generator major overhauling has been conducted in Feb-March 2021. During inspection, findings were observed on the Generator rotor J Straps which were then replaced with new. Generator inspections during the outage showed overall Generator condition as Good.

All operating parameters e.g. winding temperature, cold air temperature are in normal range.

Based on recent MOH test results Feb 2021, routine condition monitoring tests and operating conditions, *we envisage that Unit-1 Generator can be operated reliably for next 10-12 years.*

6.1.3.2. GT-3 Unit Generator

GT-3 Unit Generator is of Ercole Marrelle make and is operating satisfactorily since its commissioning. Routine offload/on load test results are showing its healthy condition.

Generator tests, e.g. Insulation Resistance, Loop Resistance of Rotor and Stator and Megger testing were conducted during October 2020, all results are satisfactory.

All operational parameter found OK. *We envisage that U-3 generator can be operated for next 10 years based on its condition and spares availability in store.*

6.1.3.3. STG-9 Unit Generator

STG-9 Unit Generator is of Alstom make and is operating satisfactorily since its commissioning. Routine offload/on load test results are showing its healthy condition. Its major overhauling has been executed in Feb-March, 2021. All electrical tests conducted for Generator Stator and Rotor during outage Feb-2021 are showing results within normal range.

All operating parameters e.g. winding temperature, cold air temperature are normal.

Based on routine condition monitoring tests and operating conditions, *we envisage that Unit-9 generator can be operated reliably for next 10 years.*

6.1.3.4. Summary of Remaining life of Module-1 Generators

Below is the summary for Remaining life of Module-1 Unit Generators derived from condition monitoring tests performed as described in preceding paragraphs;

Table 6.3: Remaining life of Module-1 Generators

Units	COD	Make	Overall Condition Rating	Overall Generator Condition	Expected Remaining life (Years)
GT-1	18-01-1987	Siemens	9	Good	10-12
GT-3	12-03-1987	Ercole Marrelle	7	Satisfactory	10
STG-9	28-01-1991	Alstom	8	Satisfactory	10
Condition Rating Criteria 1-10: Rating 9-10 = Good; Rating 7-8 = Satisfactory; Rating 4-6 = Acceptable; Rating 1-3 = Unacceptable					

6.1.4. Module-1 Unit's Step-Up Transformer 1, 3 and 9

Following are the technical Specifications for Module-1 and 2 Units' Transformers

Table 6.4: Technical specifications of Module-1 and 2 Transformers

Technical Specifications	GT-1-2	GT-3-4	STG-8-10
Make	TRAFO UNION	ANSALDO	TOSHIBA
Rated Power (MVA)	117.6/147	77/95.5	90/135
Rated Voltage KV	10.5/139	11.139	11/139
Rated Frequency (HZ)	50	50	50
No of Phases	3	3	3
Rated Current (A)	8083/611	5012/396	7090/561
Type of Cooling	ONAN/ONAF	ONAN/ ONAF	ONAN/ ONAF
Temp. Rise Winding/Oil	55/50 °C	55/50 °C	55/50 °C

6.1.4.1. Unit-1 Step-Up Transformer 1BAT01 Condition Monitoring

U-1 Step-Up Transformer testing was performed in 2019 by Siemens at the KAPCO Complex (see Appendix-2: GT-1 Unit TF 1BAT01 Life assessment).

Field testing has been carried out to identify adverse trends in the aging of the transformer and its accessories.

Siemens performed the following tests and inspection on the Power Transformers as per the following scope of work:

- Insulation Resistance and PI Test
- Transformer Turns Ratio Test
- Winding Resistance Test (HV/MV)
- Overall Capacitance and Dissipation Factor Test (Windings / Bushings)
- Leakage Reactance Test
- Excitation Current Test
- Sweep Frequency Response Analysis
- Dielectric Frequency Response Analysis
- Visual Inspection Report

Field testing performed for 1BAT01 concluded, the condition of the transformer as **Normal** as per below details

Trafo Tag No.	Tests								Overall Assessment
	IR	TTR	WR	C&DF	LR	EC	SFRA	DFRA	
01BAT	√	√	√	√	√	√	Mod	√	Normal

√: Satisfactory; X: Unsatisfactory; Mod.: Moderate; Sev: Severe; N/A: Not Applicable

Oil Analysis report for the test conducted in May 2020 has also verified the satisfactory condition of TF. Following is the conclusion from oil analysis report (Appendix-2: Unit-1 TF 1BAT01 Oil Analysis Report);

- "The evolution of the dissolved gases can be considered as normal. There is no indication of thermal or electrical faults in the transformer.
- The water content and relative saturation of the oil can be considered as normal.
- The analysis of paper ageing markers does indicate significant winding paper ageing. Based on the furans concentration the DP can be estimated between 350 and 550. When a DP-value lower than 200 is reached, the winding paper is considered as end-of-life.
- The next sample according to normal frequency. **No other action needed"**

Operating parameters of transformer e.g. Oil temperature, winding temperature etc. all are in normal range.

Thus, the overall condition of Unit-1 Step Up transformer is **Satisfactory**; that is code-1 for healthy equipment operating normally.

6.1.4.2. Unit-3 Step-Up Transformer 3BAT01 Condition Monitoring

Transformer Oil analysis tests were performed in May 2020 by LABORELEC Belgium (Appendix-2 Unit-3 TF 3BAT01 Oil Analysis Report).

Following is the conclusion from the oil analysis;

"The evolution of the dissolved gases can be considered as normal. There is no indication of thermal or electrical faults in the transformer. The oil properties that were investigated indicate severe oil degradation (high tan delta, high color, acidity). The analysis of paper ageing markers does also indicate significant winding paper ageing. The oil tests potentially corrosive."

All electrical tests conducted for Transformers are showing satisfactory results.

Operating parameters of transformer e.g. Oil temperature, winding temperature etc all are in normal range.

Thus, the overall condition of Unit-3 Step Up transformer is **Acceptable**; that is code-2 i.e. equipment can keep operating normally with increased frequency of condition monitoring test.

6.1.4.3. Unit-9 Step-Up Transformer D1BAT01 Condition Monitoring

Transformer Oil analysis tests were performed in May 2020 by M/S LABORELEC Belgium (Appendix-2 Unit-9 TF D1BAT01 Oil Analysis Report). Following is the conclusion from oil analysis;

"The evolution of the dissolved gases can be considered as relatively stable. The water content and relative saturation of the oil can be considered as normal. The analysed winding paper ageing markers (alcohols) indicate beginning of paper ageing and quality of winding paper can be assessed as still good (DP-value >600). The next sample according to normal frequency. No other action needed."

Operating parameters of transformer e.g. Oil temperature, winding temperature etc all are in normal range. Thus, the overall condition of Unit-9 Step Up transformer is **Satisfactory**; that is code-1 i.e. that is code-1 for healthy equipment operating normally.

6.1.4.4. Summary of Module-1 Units Transformer Condition Monitoring

Depending upon above assessments and the recent tests conducted for condition monitoring of unit step up transformers of module-1, healthiness is confirmed as per below summary table;

Table 6. 5: Overall Condition Assessment of Module-1 Unit Transformers

Unit	Unit Transformer	Overall Condition code	Overall Condition Status
GT-1	1BAT01	1	Satisfactory
GT-3	3BAT01	2	Acceptable
STG-9	D1BAT01	1	Satisfactory
Condition Code 1: Healthy Equipment Operating Normally Condition Code 2: Early indication of operational fault. Frequency of test is increased (usually 6 months depending on the indicated problem) until either the condition worsens or until we are satisfied that the condition is not active and we would then push the testing interval out) No abnormality of Gas, Oil and Paper condition			

6.1.5. Control System of Module-1 Units

6.1.5.1. GT-1 Control System

To enhance unit operating reliability, GT-1 old ISKMATiC control system was replaced in 2016 with state of the art fourth generation SPPA T3000 DCS of Siemens and the SFC / Excitation systems with GE Semipole D-4 versions.

The useful life of industrial electronic components is about 20 years. Hence Remaining Useful life of unit-1 control system is considered not less than 16 years.

6.1.5.2. GT-3 Control System

At GT-3, FIAT HIGH control system is in operation since commissioning. It is an old control system yet is operating satisfactorily with availability of spares in KAPCO Stores.

The existing Excitation system at GT-3 is GE Semipole D4.0 which was installed in 2017. It is a new system and spares / OEM support is available.

6.1.5.3. STG-9, HRSG-1, 3 and BOP Control System

STG-9 along with HRSG-1 and 3 and BOP; the old control system of ABB PROCONTROL Decontic K and SIEMENS TELEPERM ME has been replaced in 2016 with state-of-the-art fourth generation SPPA T3000 DCS of Siemens. It has enhanced unit availability and integrity.

Remaining Useful life of Unit-9 control system is considered not less than 16 years.

6.1.5.4. Summary of Remaining life of Module-1 Control Systems

Below is the summary of remaining life of Module-1 unit's control systems;

Table 6.6: Remaining life of Module-1 unit's control systems

Control System Module-1 GT-1, GT-3 & STG-9 Remaining Life		
Unit	Control System	Expected Remaining Life (Years)
GT 1	Siemens SPPA T3000	16
GT 3	Fiat Hi	10*
STG-9, HRSG 1 & 3 & BOP	Siemens SPPA T3000	16
*GT-3 control system may operate for next 10 years with availability of spares in KAPCO Stores		

6.1.6. Cooling Tower System for STG-9 of Module-1

Cooling Tower structure visual inspections were performed during the last schedule outages and Concrete Corrosion was reported at different locations. Civil structure water proofing and repairs were performed.

Tam Seal was applied which waterproofs and provides in-depth concrete protection. After applying the TAM sealing the cooling tower structure is observed **good**. (Also see 5.6 5.6. Buildings and Civil Structure Integrity Assessment)

Cooling Tower fan, PMs (Preventive maintenance) are performed as per manufacturer recommended intervals. PMs records are available in the computer aided maintenance management system (Q4-CAMM). Mandatory spare parts inventory is maintained.

CW Pumps and piping Inspection / life assessment was conducted by SGS and no significant marks of deterioration observed. Thereafter, inspection is carried out by KAPCO team during schedule outages and no abnormality has been observed.

It is considered that the Cooling Tower system can be operated reliably for next 12 years.

6.1.7. Water Treatment Plant Module-1 and 2

Preventative Maintenances (PMs) are performed as per manufacturer recommended intervals. PMs records are available in the computer aided maintenance management system (Q4-CAMM). Mandatory spare parts inventory is maintained. Water Treatment plants are in healthy conditions and are operating without any trouble.

It is considered that the Water Treatment Plants can be operated reliably for next 12 years.

6.2. Module-2 Plant Components' Residual Life Assessment

6.2.1. Gas Turbine Unit 2, 4 and Steam Turbine Unit-10

Gas Turbine GT-2: Hot gas path components are being replaced periodically on MOH as per recommended EOH by the OEM Siemens. One complete set of turbine vanes and blades is available as a strategic spare.

The overall condition of GT-2 was observed as Satisfactory during visual inspections and NDTs performed in the last MOH/eHGPI Feb-March 2018.

Scope of visual inspection and NDTs included;

- Ultrasonic Testing of Compressor bearing, Turbine bearing, Gas Burner, Compressor vanes,
- Magnetic Particle Test of Compressor vane carrier, Compressor blades, Rotor, Compressor and Turbine wheel discs, Intermediate shaft, Front Hollow shaft, Compressor and Turbine vane carriers, Bearings, etc.
- Dye Penetrant Test was performed for Compressor and Turbine bearing, Compressor vane rings, Gas Premix Burners, Mixing chamber of combustion chambers, Inner Casing, Turbine stator vanes stage-4, Compressor and Turbine vane carriers, exhaust casing etc.

Overall NDT results were categorized Acceptable except few observations which were addressed in MOH activities e.g. Inner Casing ground out and build-up welding.

Air intake system structure is in healthy condition. New air intake filters are available in the market.

The compressor blades stages 1-12 have been in service since commissioning. New compressor blades stages 13-16 were installed in 2002 and are in service since then. During inspection in the last MOH Feb-March 2018, no recordable indication was reported in NDT report March 2018 and the condition of compressor blades were found to be satisfactory. In case if some findings appear in the next MOH, compressor blades are recommended to be replaced.

New IGVs were installed in 2009 and expected remaining useful life is 10-15 years henceforth.

All stages of GT-2 compressor diaphragms were replaced during the 2002 MOH with new ones. The condition of the compressor diaphragms was found satisfactory in the MOH 2018.

Gas Turbine GT-4: Hot gas path components are being replaced periodically with each MOH as per recommended EOH by OEM. One set of vanes and blades is available in store as a strategic spare.

New Compressor blades were installed in 1999 and are in service without any findings.

The overall condition of GT-4 was found to be satisfactory during the MOH 2016 and HGPI 2017. One complete GT rotor is available for GT-3 and GT-4 as a strategic spare.

Steam Turbine STG-10 condition found satisfactory during last Minor Inspection Feb-April 2016. Last MOH was performed in Sep-Oct 2013. During the MOH, modified 1st stage moving blades and new LP turbine erosion protection rings of the last 3 stages were installed which enhance turbine performance and integrity.

Mandatory spares are maintained for the steam turbine and are available in store.

Following is the expected Remaining Life summary of Module-2 units as per current operating regime;

Table 6. 7: Remaining Life of Module-2 Units

Unit #	Operating Hours In Design Life of 30 years	Operating Hours in Extended Design Life of 40 years*	KAPCO Operating Hours COD to Mar-2021	Remaining Operating Hours In Extended Design Life of 40 years	Remaining Design life (Years)
GT-2	240,000	320,00	162,106	157,894	20
GT-4	240,000	320,00	93,756	226,244	28
STG-10	240,000	320,00	157,017	162,983	20

Module-2 Units are expected to operate for minimum further 10 years without any major concern.

*CCGT Operating Life expectancy before retirement is 40 years (320,000 hours based on 8,000 operating hours/year) ref section 5.3.4 and 5.4 of this document.

6.2.2. Module-2 HRSG 2 and 4

HRSG-1 to 4 are of same model and make of Balke Durr Germany. All four Heat Recovery steam generators have operated satisfactorily since their commissioning.

Life assessment of HRSG-1 was conducted on sample basis among all four HRSGs of Block-1 (Module-1 and 2). No major deterioration was reported with remaining life of all major components greater than 20 years. The same condition about life assessment is predicted for the other three HRSGs i.e. HRSG-2, 3 and 4 as these HRSGs have fewer operating hours and have generally been operated and maintained the same.

Also, HRSG-2 and 4 mandatory inspections are carried out in every schedule outage of GT-2 and GT-4 by the Boiler Engineer, Mechanical Engineer and Plant Chemist.

Last inspection was performed in Feb 2021 and both HRSGs condition were found to be satisfactory.

Based on life assessment reports and routine maintenance inspections; it is expected that with the current operating regime, *HRSG-2 and 4 may be operated reliably for next 12-15 years.*

6.2.3. Module-2 Unit's Generators

6.2.4. GT-2 Unit Generator

GT-2 Unit Generator is of Siemens make and is operating satisfactorily since its commissioning. Its overhauling has been performed in Feb, 2018 under Siemens' Engineers supervision.

The following inspections and major tests were conducted:

- Visual inspection of generator end windings in accessible area

- Visual inspection of bar connections
- Visual inspection of Z brackets
- Partial discharge test
- Rotor Insulation Resistance Test
- Stator insulation Resistance test
- ELCID
- RSO

Siemens' Engineers reported "No thermal or thermo mechanical aging phenomena were detected. Reliability is not currently limited for the next operating period"

Overall condition of Generator is Good. *It is considered that Unit-2 Generator can be operated for the next 10 years.*

6.2.4.1. GT-4 Unit Generator

GT-4 Unit Generator is of Ercole Marrelle make and has operated satisfactorily since its commissioning. Aging impacts were evident on a few parts e.g. cooler leakages etc which were addressed. Generator tests, e.g. Insulation Resistance, Loop Resistance of Rotor and Stator and Megger tests were conducted during Sep 2019, all results are satisfactory.

All operational parameter found OK. Overall condition of Generator is Satisfactory. *We envisage that U-4 generator can be operated for next 10 years based on its condition and with spares availability in store.*

6.2.4.2. STG-10 Unit Generator

STG-10 Unit Generator is of Alstom make and is operating satisfactorily since its commissioning in January 1991. Alstom overhauled the Generator in 2016. Overall condition of Generator is considered Good.

However, Alstom stated for displaced U-channels of the rotor "The current state of displacement doesn't require immediate actions, since the cooling gas-inlets are still free and the insulation distance is still sufficient for the operating voltage. The displacement is likely to get bigger with further operation, eventually blocking the cooling gas-inlets or decreasing the insulation distance (creep age path) to a point where an earth-fault (contact of rotor winding with rotor body) is possible. Alstom recommended; 1) To monitor the displacement of the slot channels regularly at least once a year. 2) To measure and protocol (trend) the insulation resistance at least once a year. 3) The rotor earth fault protection should be checked and kept in good working order.

All operational parameter found OK. Recent electrical tests conducted are showing results normal.

Based on routine condition monitoring tests and operating conditions, *we envisage that U-10 Generator can be operated reliably for next 10 years.*

6.2.4.3. Summary for Remaining life of Module-2 Generators

Below is the summary for Remaining life of Module-2 Unit's Generator derived from condition monitoring tests performed as described in preceding paragraphs;

Table 6. 8: Remaining life of Module-2 Generators

Units	COD	Make	Overall Condition Rating	Overall Generator Condition	Expected Remaining life (Years)
GT-2	14-01-1987	Siemens	8	Satisfactory	10
GT-4	02-05-1987	Ercole Marrelle	7	Satisfactory	10
STG-10	08-01-1991	Alstom	9	Good	10
Condition Rating Criteria 1-10: Rating 9-10 = Good; Rating 7-8 = Satisfactory; Rating 4-6 = Acceptable; Rating 1-3 = Unacceptable					

6.2.5. Module-2 Unit's Step-Up Transformer 2, 4 and 10

6.2.5.1. Unit-2 Step-Up Transformer 2BAT01 Condition Monitoring

GT-2 Unit Step-Up Transformer testing was performed for life assessment by ABB in 2016 on a sample basis in Block-1 units.

ABB performed the following tests along with visual inspection of the Power Transformers as per the specified scope of work:

- Winding Turn Ratio Test
- Vector Group Check
- Excitation Current Test
- Winding DC Resistance Test
- Winding Insulation Resistance Test
- Winding Tan Delta Test
- Winding Tan Delta Test
- FRA Frequency Response Analysis

All tests results were observed acceptable.

Also, the Transformer Oil analysis tests were performed in May 2020 by LABORELEC Belgium (Appendix-2 Unit-2 TF 2BAT01 Oil Analysis Report). Following is the conclusion from the oil analysis;

"The evolution of the dissolved gases (DGA) shows decreased concentrations. No indication of any specific evolving internal transformer fault.

The water content and relative saturation of the oil can be considered as normal.

The analysis of paper ageing markers does indicate significant winding paper ageing. Based on the furans concentration the DP can be estimated between 375 and 575. When a DP-value lower than 200 is reached, the winding paper is considered as end-of-life.

The next sample according to normal frequency. **No other action needed.**"

Furan Analysis report results are similar for test report 2019 and 2020 which shows no immediate concern for future operations.

Operating parameters of transformers e.g. Oil temperature, winding temperature all are in normal range.

Field testing performed for 2BAT01 concluded, condition of transformer as **Satisfactory** that is code-1 for healthy equipment operating normally.

6.2.5.2. Unit-4 Step-Up Transformer 4BAT01 Condition Monitoring

Transformer Oil analysis tests were performed in May 2020 by M/S LABORELEC Belgium (Appendix-2 Unit-4 TF 4BAT01 Oil Analysis Report). Following is the conclusion from the oil analysis;

"The evolution of the dissolved gases can be considered as stable. The water content and relative saturation of the oil can be considered as normal. The oil properties that were investigated indicate minor oil degradation.

The analysis of paper ageing markers does indicate limited winding paper ageing. Based on the furans and methanol concentration the DP can be estimated as >600 and the paper can still be considered as in good condition.

The next sample according to normal frequency. **No other action needed at this stage.**"

Operating parameters of transformers e.g. Oil temperature, winding temperature all are in normal range.

Thus, the overall condition of Unit-3 Step-Up transformer is **Satisfactory**; that is code-1 i.e. for healthy equipment operating normally.

6.2.5.3. Unit-10 Step-Up Transformer D2BAT01 Condition Monitoring

Transformer Oil analysis tests were performed in May 2020 by M/S LABORELEC Belgium (Appendix-2 Unit-10 TF D2BAT01 Oil Analysis Report). Following is the conclusion from oil analysis;

"The evolution of the dissolved gases shows an increase compared to the previous sample (01/2019) and shows similar gas pattern the sample of 05/2018 which can indicate that the previous sample was not from this transformer/ the right place. Nevertheless, the concentrations are also increased compared to the sample of 05/2018. Laborelec recommends to send a new sample within 3 - 6 months in order to follow-up the evolution. The concentrations of the gases can indicate the presence of overheating fault type (insufficient cooling or overloading) or possible stray gassing.

The water content and relative saturation of the oil can be considered as normal." New sample for oil analysis will be sent in 2021.

All electrical tests conducted are showing results in normal range.

Operating parameters of transformers e.g. Oil temperature, winding temperature all are in normal range.

Thus overall condition of Unit-10 Step Up transformer is **Satisfactory**; that is code-1 i.e. for healthy equipment operating normally.

6.2.5.4. Summary of Module-2 Unit's Transformer Condition Monitoring

Depending upon the above assessments and the recent tests conducted for condition monitoring of the Unit step-up transformers of Module-2, healthiness is confirmed as per below summary table;

Table 6.9: Overall Condition Assessment of Module-2 Unit Transformers

Unit	Unit Transformer	Overall Condition code	Overall Condition Status
GT-2	1BAT01	1	Satisfactory
GT-4	4BAT01	1	Satisfactory
STG-10	D1BAT01	1	Satisfactory
Condition Code 1: Healthy Equipment Operating Normally Condition Code 2: Early indication of operational fault. Frequency of test is increased (usually 6 months depending on the indicated problem) until either the condition worsens or until we are satisfied that the condition is not active and we would then push the testing interval out) No abnormality of Gas, Oil and Paper condition			

6.2.6. Control System of Module-2 Units

6.2.6.1. GT-2 Control System

To enhance unit operating reliability, the GT-2 old ISKMATIC control system was replaced in 2013 with state of the art fourth generation SPPA T3000 DCS of Siemens and the SFC / Excitation systems with GE Semipole D-4 versions.

The useful life of industrial electronic components is about 20 years. *Hence Remaining Useful life of Unit-2 control system is considered not less than 13 years.*

6.2.6.2. GT-4 Control System

At GT-4, the FIAT HIGH control system has operated since commissioning. It is an old control system yet operating satisfactorily with availability of spares in KAPCO Stores.

6.2.6.3. STG-10, HRSG-1, 3 and BOP Control System

STG-10 along-with HRSG-2 and 4 and BOP; is operating with the old control system of ABB Procontrol Decontic K and Siemens Teleperm ME. STG-10 control system is operating reliably with spares availability in KAPCO Stores. Moreover, spares obtained from STG-9 control system replacement are available for STG-10.

Below is the summary of Remaining life of Module-2 Units' control system;

Table 6. 10: Remaining life of Module-2 Unit's control systems

Control System Module-2 GT-2, GT-4 & STG-10 Remaining Life		
Unit	Control System	Expected Remaining Life (Years)
GT 2	Siemens SPPA T3000	13
GT 4	Fiat Hi	10*
STG-10, HRSG 2 & 4 & BOP	ABB Procontrol Decontic K & Siemens Teleperm ME	10**
*GT-4 control system may operate for next 10 years with availability of spares in KAPCO Stores		
**STG-10 control system may operate for next 10 years with availability of spares in KAPCO Stores and additional spares obtained from Control System replacement of STG-9.		

6.2.7. Cooling Tower System for STG-10 of Module-2

Cooling Tower structure visual inspections were performed during the last schedule outage. Concrete Corrosion was observed at different locations. Civil structure water proofing and repairs were performed.

Tam Seal was applied which waterproofs and provides in-depth concrete protection. After applying the TAM sealing cooling tower structure is observed good. (Also see 5.6 5.6. Buildings and Civil Structure Integrity Assessment)

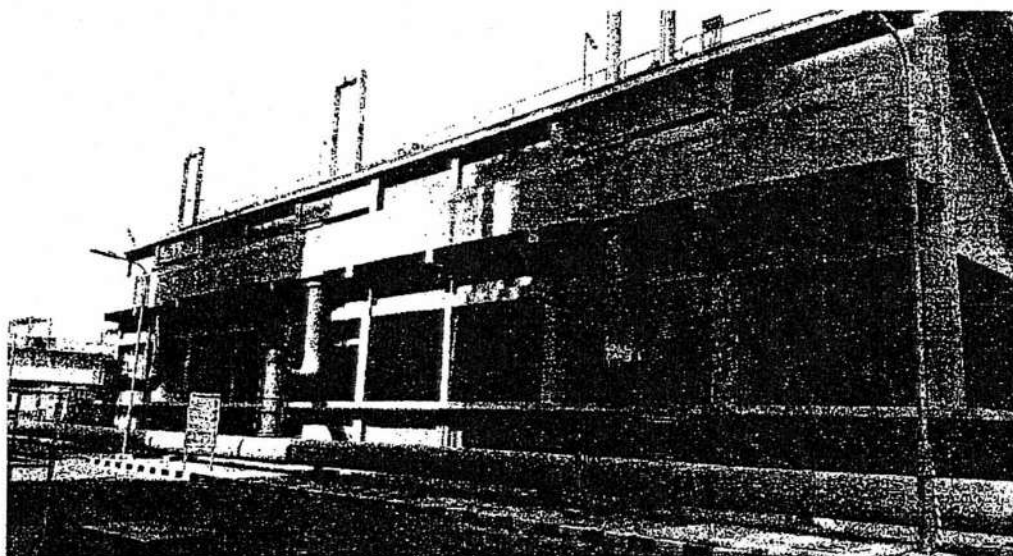


Figure 6. 1: Cooling Tower STG-10

Cooling Tower fan, PMs (Preventive maintenance) are performed as per manufacturer recommended intervals. PMs records are available in the computer aided maintenance management system (Q4-CAMM). Mandatory spare parts inventory is maintained.

CW Pumps and piping Inspection is carried out by KAPCO team during schedule outages and no abnormality of great concern observed.

It is expected that the Cooling Tower system can be operated reliably for the next 12 years.

6.3. Module-3 Plant Components' Residual Life Assessment

6.3.1. Gas Turbine Unit 5, 6 and Steam Turbine Unit-11

Gas Turbine GT-5: Hot gas path components are being replaced periodically on CI, HGPI and MOH as per recommended EOH intervals by the OEM (GE). A minimum of one complete set of turbine buckets and nozzles is always available in store as a strategic spare.

One complete refurbished GT rotor is available for GTs-5 to 8 as a strategic spare. One complete set of compressor blades are also available as a strategic spare.

GT-5 compressor and turbine rotor was replaced with a refurbished rotor in 2011 and 2003 respectively. The compressor blades have been in service since commissioning and the overall condition is satisfactory.

The overall condition of Gas Turbine-5 unit was observed as being Good during inspections performed in HGPI Sep-Oct 2017.

The compressor casings have been in operation since commissioning. During inspections performed, no major observations were noted. Therefore, compressor casings may be kept in operation for next 10 years satisfactorily.

No major observations were noted for the Compressor Stator/Diaphragms, so keeping in view the present condition, these may also be kept in operation for next 10 years.

Gas Turbine GT-6: Hot gas path components are being replaced periodically on CI, HGPI and MOH as per recommended EOH intervals by the OEM (GE).

GT-6 compressor and turbine rotor was replaced with new and refurbished rotors in 1996 and 2006 respectively. The compressor blades have been in service since commissioning.

The overall condition of Gas Turbine-6 unit was observed as being Good during inspections performed in HGPI Sep-Oct 2017.

For Compressor Casings, during inspections performed in HGPI Sep-Oct 2017, no major observation has been noted. Therefore, it is considered that the compressor casings may be kept in operation for the next 10 years satisfactorily.

No major observations were noted for Compressor Stator/Diaphragms, so keeping in view the present condition, these may also be kept in operation for the next 10 years.

GT-5 and 6 hot gas path up-gradation was performed during the outage in Oct-Nov 2011, replacing components with improved metallurgy and design supplied by the OEM which also improved the Units' performance and enhanced the plant life.

Steam Turbine STG-11 schedule maintenance is performed as per OEM recommendations. Spares inventory is maintained in KAPCO Stores (See Appendix-6 for Strategic Spares)

STG-11 last Overhauling was conducted in Feb-March 2020.

The Turbine upper casing was removed. No cracks in the casing and other abnormalities were observed.

DPT of Turbine diaphragms was performed by Jiaco, Pakistan and no major abnormality was observed. Minor observation on the lower half diaphragm of Stage # 13 was addressed.

The Turbine rotor was removed and the corrosion condition of the blades was found to be found normal. Minor scaling was observed on the lower pressure side of rotor. Last stage blading was observed to be in good condition and all brazed leading edges were found to be intact. All blades were cleaned with sand-papers. Magnetic particle testing of all rotor stages was carried out. No cracks or other abnormalities were observed. Some of the gland seal packing was found to be bent, which were straightened. Gland seals were also found in good condition. Condition of the rotor was found satisfactory.

The overall condition of Steam Turbine Unit-11, including condenser, was observed to be satisfactory during inspections performed in MOH Sep-Oct 2017 and last Minor Overhauling Feb-March 2020.

Following is the expected Remaining Life Assessment summary of Module-3 units as per unit's condition and current operating regime;

Table 6. 11: Remaining Life of Module-3 Units

Unit #	Operating Hours in Design Life of 30 years	Operating Hours in Extended Design Life of 40 years*	KAPCO Operating Hours COD to Mar-2021	Remaining Operating Hours in Extended Design Life of 40 years	Remaining Design life (Years)
GT-5	240,000	320,00	144,150	175,850	22
GT-6	240,000	320,00	152,072	167,928	21
STG-11	240,000	320,00	128,560	191,440	24
<p>Module-3 Units are expected to operate for minimum further 10 years without any major concern.</p> <p>*CCGT Operating Life expectancy before retirement is 40 years (320,000 hours based on 8,000 operating hours/year) ref section 5.3.4 and 5.4 of this document.</p>					

6.3.2. Module-3 HRSG 11A and 11B

HRSGs 11A, 11B, 12A and 12B are of same model and make of Stein Industries France. All four Heat Recovery steam generators have operated satisfactorily since their commissioning.

Life assessment of HRSG-11A and 11B was conducted in Nov-2020 by SGS Pakistan on a sample basis among all four HRSGs of Block-2 (Module-3 and 4). The same condition about life assessment is predicted for HRSG-12A and 12B having almost same service life and operating conditions.

During inspections relating to life assessment for HRSG-11A and 11B no significant deterioration was observed except a few recommendations of improvement which are addressed e.g. Recommendation for HRSG-11A Corroded Insulation cladding outside HP Economizer (and HP Superheater for HRSG-11B) need to repair or replace. Hence, the corroded Insulation cladding outside HP Economizer (and HP Superheater for HRSG-11B) was replaced with new one as per recommendation.

(see Appendix-1: Remnant Life assessment of HRSG-11A and 11B).

Following inspection techniques were used for life assessment study of HRSG-11A and 11B.

- Visual Inspections
- Ultrasonic Thickness Measurement
- Ultrasonic Flaw Detection
- Dye Penetrant Testing
- Magnetic Particle Inspection
- Hardness Testing
- Metallographic examination

Scope of work for complete inspection and remaining life assessment of HRSG-11A and 11B included following inspections and NDTs;

- Visual inspection of HP drum, tubes, headers, for localized and uniform corrosion, deposits, erosion, pitting etc.
- Visual inspection of protective coating/insulation for damages
- Visual inspection for corrosion under insulation (CUI)
- Visual inspection of all structural steel parts including ducts, platforms, handrails and structural steel supports for ducts/piping for any visual defects.
- Visual inspection of tube bends and headers
- Visual inspection and DPT of steam header pipe welds for cracks
- Visual inspection of all accessible weld joints of HP Drum/LP separator, like shell, heads and nozzles.
- Hardness testing of HP drum, LP Separator and headers. 14 Locations from tube, 2 from each header, 4 locations from inside the drums
- Ultrasonic flaw detection of suspected weld joints of HP drum, LP Separator.
- MPI/DPT of selected weld joints
- Metallographic testing of boiler pressure parts like 2 from each HP drum, 1 for each LP Separator, 1 from each header to study the metallurgical changes, degradation and evaluation for its fitness for service.
- Ultrasonic thickness gauging was carried out from accessible locations, on the recommendations of API-510 inspector to find out overall metal loss in different equipment for remaining life calculations.

Remaining Life of HRSG-11A and 11B was calculated, comparing component's thickness at installation and current thickness gauging 2020 using remaining corrosion allowance.

For HRSG-11A all major components' remaining life is calculated greater than 40 years while HP Super Heater Outlet Header remaining life is calculated as 19.7 years.

For HRSG-11B all major components' remaining life is calculated greater than 45 years.

Also, HRSG-11A and 11B mandatory inspections are carried out in every schedule outage of GT-5 and GT-6 by the Boiler Engineer, Mechanical Engineer and Plant Chemist.

Last inspection was performed in March 2020 and both HRSGs condition found to be satisfactory.

Based on life assessment report and routine maintenance inspections; *we expect that with the current operating regime, HRSG-11A and 11B can be operated reliably for next 10-15 years.*

6.3.3. Module-3 Unit's Generators

Following are the technical Specifications for Module-3 and 4 Units' Generators

Table 6.12: technical specifications of Module-3 and 4 Generators

Technical Specifications	GT-5-8	STG-11-12
Type:	T 229-320	T-229-320
Make:	ALSTHOM	ALSTHOM
Rated Out Put (MVA):	125.95	121.647
Power Factor:	0.85	0.85
Rated Voltage (KV):	11.5	11.5
Rated Current (A):	6223	6107
Frequency (HZ):	50	50
Gen Cooling System	Air Cooled	Air Cooled
Cold air temp	50°C	36°C

6.3.3.1. GT-5 Unit Generator

Condition monitoring testing of the Generator stator winding was carried out in Sep- 2015 by OEM (Alstom). On the basis of the tests, conductive paint activity on the stator winding was carried out in Sep-2015.

Generatortech flux probe was also installed to monitor Generator rotor healthiness during an outage in September 2015. Recent tests were conducted in Jan 2021 and data collected from the Generatortech flux probe. The quality of the flux probe waveforms were observed to be excellent. Analysis of the complete dataset shows very clearly there are no turn shorts in the GT-5 Generator rotor winding.

Installation of PD sensors by IRIS Canada was completed in Nov-2017 and hence PD monitoring started. PD Data collected for Jan 2021 has been analysed and summarized with the conclusion "Stable winding PD and low level, interphasal activity." Hence PD test results show healthy condition of the Generator Stator.

Generator rotor flux report and PD test Jan 2021 indicate that there is no significant faults on the Generator Rotor and Stator and it can continue its normal operation and hence Generator overall condition is considered to be **Satisfactory**.

Full Stator rewind Material (FSR) is available on-site as Strategic spare for GT-5, 6 and 7 Stators

We envisage that Unit-5 Generator can be operated for next 10 years based on current operating data and strategic spares availability in KAPCO stores.

6.3.3.2. GT-6 Unit Generator

Condition monitoring testing of the Generator stator winding has been carried out in Sep- 2015 by OEM (Alstom). On the basis of tests, conductive paint activity on the stator winding was carried out in Sep-2015.

Generatortech flux probe was also installed to monitor Generator rotor healthiness during the outage in October 2017. Recent tests conducted in Jan 2021 and data collected from the Generatortech flux probe

were analysed. The quality of the flux probe waveforms were observed to be excellent. Analysis of the complete dataset shows very clearly there are no turn shorts in the GT-6 Generator rotor winding.

Installation of PD sensors was completed in March 2019 during the outage. PD Data collected for Jan 2021 has been analysed and summarized with the conclusion "Increase in PD and low level, interphasal, deterioration of surface coatings". Hence PD test results show condition of Generator Stator Satisfactory.

Generator rotor flux report and PD test Jan 2021 indicate that there is no signification fault on Generator Rotor and Stator and it can continue its normal operation and, hence Generator overall condition is considered to be Satisfactory.

We envisage that Unit-6 Generator can be operated for the next 10 years based on current operating data and strategic spares availability in KAPCO stores.

6.3.3.3. STG-11 Unit Generator

On the basis of Conditioning Monitoring tests, Full stator rewind of STG-11 generator was completed in Sep/Oct 2017.

Generatortech flux probe was also installed to monitor the Generator rotor healthiness during the outage in October 2017. Recent tests conducted in Jan 2021 and data collected from the Generatortech flux probe were analysed. The quality of the flux probe waveforms were observed to be excellent. Analysis of the complete dataset shows very clearly there are no turn shorts in the STG-11 Generator rotor winding.

Installation of PD sensors was completed in March 2019 during the outage. PD Data collected for Jan 2021 has been analysed and summarized with conclusion "stable (slight decrease) winding PD and Typical level". Hence PD test results show condition of Generator Stator Good.

Generator rotor flux report and PD test Jan 2021 indicates that there is no fault on the Generator Rotor and Stator and, hence Generator overall condition is Good.

We expect that newly rewound STG-11 Generator may be kept in operation reliably for the next 20-25 years.

6.3.3.4. Summary for Remaining life of Module-3 Generators

Below is the summary for Remaining life of Module-3 Unit Generators in view of condition monitoring described in preceding paragraphs;

Table 6. 13: Remaining life of Module-3 Generators

Units	COD	Make	Overall Condition Rating	Overall Generator Condition	Expected Remaining life (Years)
GT-5	14-11-1988	Alsthom	8	Satisfactory	10
GT-6	29-12-1988	Alsthom	7	Satisfactory	10
STG-11	04-03-1995	Alsthom	9	Good	20

Condition Rating Criteria 1-10:

Rating 9-10 = Good; Rating 7-8 = Satisfactory; Rating 4-6 = Acceptable; Rating 1-3 = Unacceptable

6.3.4. Module-3 Unit's Step-Up Transformer 5, 6 and 11

Following are the technical Specifications for Module-3 and 4 Units' Transformers

Table 6.14: technical specifications of Module-3 and 4 Transformers

Technical Specifications	GT-5-8	STG-11-12
Make	ALSTHOM	ALSTHOM
Rated Power (MVA)	125	112/125
Rated Voltage KV (LV/HV)	11.5/240	11.5/240.18
Rated Frequency (HZ)	50	50
No of Phases	3	3
Rated Current (A) LV/HV	6276/300	6276/300
Type of Cooling	ONAN/ONAF	ONAN/ ONAF
Temp. Rise Winding/Oil	55/50 °C	55/50 °C

6.3.4.1. GT-5 Unit Transformer 5BAT01 Condition Monitoring

Transformer Oil analysis tests were performed in May 2020 by LABORELEC Belgium (Appendix-2 Unit-5 TF 5BAT01 Oil Analysis Report). Following is the conclusion from the oil analysis;

"The evolution of the dissolved gases can be considered as relatively stable. This gas pattern indicates low temperature overheating (high load, insufficient cooling, ...) or stray gassing of the insulating oil.

The water content and relative saturation of the oil can be considered as normal.

The breakdown voltage acceptable for this type of transformer. The other properties that were investigated can be considered as normal.

The analysed winding paper ageing markers (furans, methanol) indicate no significant paper ageing and thus quality of winding paper can be assessed as very good (DP-value >800).

The next sample according to normal frequency. **No other action needed."**

Operating parameters of transformer e.g. Oil temperature, winding temperature all are in normal range.

Thus, the overall condition of Unit-5 Step Up transformer is **Satisfactory**; that is code-1 i.e. for healthy equipment operating normally.

6.3.4.2. GT-6 Unit Transformer 6BAT01 Condition Monitoring

Transformer Oil analysis tests were performed in May 2020 by LABORELEC Belgium (Appendix-2 Unit-6 TF 6BAT01 Oil Analysis Report). Following is the conclusion from oil analysis;

"The evolution of the dissolved gases can be considered as normal. There is no indication of thermal or electrical faults in the transformer.

The water content and relative saturation of the oil can be considered as normal. The properties that were investigated can be considered as normal.

The analysed winding paper ageing markers (furans, methanol) indicate no significant paper ageing and thus quality of winding paper can be assessed as very good (DP-value >800).

The next sample according to normal frequency. **No other action needed."**

Operating parameters of transformer e.g. Oil temperature, winding temperature all are in normal range.

Thus, the overall condition of Unit-6 Step Up transformer is **Satisfactory**; that is code-1 for healthy equipment operating normally.

6.3.4.3. STG-11 Unit Transformer 11CGEV001TR Condition Monitoring

Transformer Oil analysis tests were performed in May 2020 by LABORELEC Belgium (Appendix-2 Unit-11 TF 11CGE V001TF Oil Analysis Report). Following is the conclusion from the oil analysis;

"The evolution of the dissolved gases can be considered as acceptable. This gas pattern indicates low temperature overheating (high load, insufficient cooling, ...) or stray gassing of the insulating oil.

The water content and relative saturation of the oil can be considered as normal. The properties that were investigated can be considered as normal.

The analysed winding paper ageing markers (furans, methanol) indicate no significant paper ageing and thus quality of winding paper can be assessed as very good (DP-value >800).

The next sample according to normal frequency. **No other action needed"**.

Operating parameters of transformer e.g. Oil temperature, winding temperature all are in normal range.

Thus, the overall condition of Unit-11 Step Up transformer is **Satisfactory**; that is code-1 for healthy equipment operating normally.

6.3.4.4. Summary Module-3 Unit's Transformer Condition Monitoring

Depending upon the above assessments and the recent tests conducted for condition monitoring of unit step up transformers of Module-3 described in preceding section, healthiness is confirmed as per below summary table;

Table 6.15: Overall Condition Assessment of Module-3 Unit Transformers

Unit	Unit Transformer	Overall Condition code	Overall Concition Status
GT-5	5BAT01	1	Satisfactory
GT-6	6BAT01	1	Satisfactory
STG-11	11CGEV001TR	1	Satisfactory

Condition Code 1: Healthy Equipment Operating Normally
 Condition Code 2: Early indication of operational fault. Frequency of test is increased (usually 6 months depending on the indicated problem) until either the condition worsens or until we are satisfied that the condition is not active and we would then push the testing interval out) No abnormality of Gas, Oil and Paper condition

6.3.5. Control System of Module-3 Units

6.3.5.1. GT-5 and 6 Control System

GT-5 and 6 Control system is GE's latest Unit Control System Mark VIe which was installed in 2015. The useful life of industrial electronic components is about 20 years, *hence, the Remaining Useful life of Unit-5 and 6 control system is considered to be 15 years.*

6.3.5.2. STG-11 Control System

The control system for STG-11 is the ALSTOM ALSPA Controsteam V3 which was upgraded in 2009. The system is currently in production with a newer version. Spare parts have been maintained and support is available.

6.3.5.3. STG-11 Aux, HRSG-11A and 11B, and BOP Control System

STG-11 Aux, HRSG-11A and 11B and BOP old Control system T20 Micro Z of ALSTOM has been replaced with a new control system RX3I of General Electric (GE) in March 2020 which has enhanced the system integrity of the Boilers, Turbine Auxiliaries and BOP control system.

6.3.5.4. Summary of Module-3 Units Control System

Below is the summary of remaining life of Module-3 Unit's Control system

Table 6.16: Remaining life of Module-3 Unit's control systems

Control System Module-3 GT-5, GT-6 & STG-11		
Unit	Control System	Expected Remaining Life(Years)
GT 5 & 6	GE Speedtronic Mark VIe	15
STG-11	Alstom ALSPA Controsteam V3	10
STG-11 Aux, HRSG-11A & B, & BOP	GE RX3I	19

6.3.6. Cooling Tower System for STG-11 of Module-3

The Cooling Tower structure visual inspection is performed twice a year during schedule outage. Concrete Corrosion was observed at different locations. Civil structure water proofing and repairs has been performed. Tam Seal 10-F has been applied which waterproofs and provides in-depth concrete protection. After applying the TAM sealing the cooling tower structure is observed Satisfactory.

Cooling Tower fan, PMs (Preventive maintenance) are performed as per manufacturer recommended intervals. PMs records are available in the computer aided maintenance management system (Q4-

CAMIM). Mandatory spare parts inventory is maintained e.g. 2 refurbished gearboxes for the cooling tower fan are available as spares. Overall condition of cooling tower fans is considered to be Satisfactory.

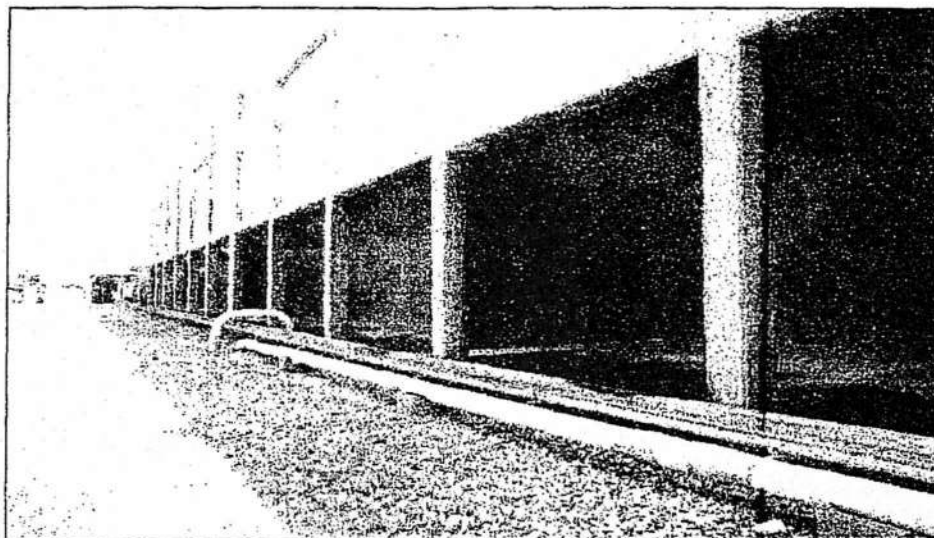


Figure 6. 2: Cooling Tower STG-11

CW Piping inspection is carried out by KAPCO team during schedule outages and piping condition is satisfactory.

CW Pumps were inspected during last schedule outage March 2020 and no abnormality observed.

As per above visual inspections and current condition monitoring it is envisaged that the Cooling Tower System can be operated reliably for the next 12 years.

6.4. Module-4 Plant Components' Residual Life Assessment

6.4.1. Gas Turbine Unit 7, 8 and Steam Turbine Unit-12

Gas Turbine GT-7: Hot gas path components are being replaced periodically on CI, HGPI and MOH as per recommended EOH intervals by the OEM (GE). One complete set of turbine buckets and nozzles is always available in store as a strategic spare.

GT-7 compressor and turbine rotor was replaced with a new one in 2005 and 2003 respectively.

The overall condition of Gas Turbine-7 unit was observed to be Satisfactory during visual inspections and NDTs performed in the recent MOH Feb-March 2021. Bearings 1, 2, 3 and the thrust bearing were replaced during the outage activities. All hot gas path components including turbine blades and vanes were replaced as per OEM recommended interval.

It is recommended by the OEM to replace the compressor aft brush seals and honey-comb seals in the next major inspections, or whenever the inner barrel is removed, for better performance.

The Compressor Casings are the original installed. During inspections performed in the recent MOH, no major observation has been noted. Therefore, it is anticipated that the compressor casings may be kept in operation for the next 10-12 years satisfactorily.

No major observation has been noted for the Compressor Stator/Diaphragms, Turbine Vane carriers etc. so keeping in view the present condition, these may also be kept in operation for next 10-12 years.

Gas Turbine GT-8: Hot gas path components are being replaced periodically on CI, HGPI and MOH as per recommended EOH intervals by the OEM (GE).

The GT-8 Compressor and turbine rotor were in service since 2002 and 2007 but were replaced in Feb 2019 with a refurbished, compressor and turbine rotor. Expected life of the GT rotor is assessed to be 15 years.

The Compressor Casings are the original installed. During inspections performed, no major observation has been noted. Therefore, it is anticipated that the compressor casings may be kept in operation for next 10 years satisfactorily.

No major observation has been noted for the Compressor Stator/Diaphragms, so keeping in view the present condition, these may also be kept in operation for next 10 years.

Overall condition of Gas Turbine-8 unit was observed to be **Good** during visual inspections and NDTs performed in the Major Outage Feb 2019.

GT-7 and 8 hot gas path up-gradation was performed in the Outages Sep-Oct 2010 and 2011 respectively, replacing components with improved metallurgy and design supplied by the OEM, which also improved the Units' performance and enhanced the plant life.

Steam Turbine STG-12 Turbine Rotor was found satisfactory during the last major inspection in Feb-March, 2017. Also, the same is noted by the GE Inspection Engineer in the Major Overhaul report of Feb-Mar, 2015.

Turbine Diaphragms were inspected and repaired through welding by the company, KPS, in the last outage of Feb-March, 2017. Last stage blading's stellite strips were also replaced.

The overall condition of Steam Turbine Unit-12 and condenser was observed to be **Good** in visual inspections and NDTs performed during the last outages in 2017 and 2018.

In Feb 2021, Minor Inspection of STG-12 was conducted, the condition of Turbine and Turbine bearings were assessed and found normal.

Following is the expected Remaining Life Assessment summary of Module-4 units as per the current operating regime;

Table 6.17: Remaining Life of Module-4 Units

Unit #	Operating Hours in Design Life of 30 years	Operating Hours in Extended Design Life of 40 years*	KAPCO Operating Hours COD to Mar-2021	Remaining Operating Hours In Extended Design Life of 40 years	Remaining Design life (Years)
GT-7	240,000	320,00	152,405	167595	21
GT-8	240,000	320,00	157,488	162512	20
STG-12	240,000	320,00	139,812	180188	23

Module-4 Units are expected to operate for minimum further 10 years without any major concern.

*CCGT Operating Life expectancy before retirement is 40 years (320,000 hours based on 8,000 operating hours/year) ref section 5.3.4 and 5.4 of this document.

6.4.2. Module-4 HRSG 12A and 12B

HRSG-11A, HRSG-11B, HRSG-12A and HRSG12-B are of the same model and make of Stein Industries. All four Heat Recovery steam generators have operated satisfactorily since their commissioning in 1995.

Life assessment of HRSG-11A and B has been conducted in Nov 2020 on a sample basis among all four HRSGs of Module-3 and 4. No major deterioration was reported with remaining life of all major components greater than 20 years. The same condition about life assessment is predicted for the other two HRSGs HRSG-12A and 12B having almost same service life and operating conditions.

HRSG-12B inspections relating to life assessment were also conducted by the company, Inspectest, in 2013 which shown similar results.

Also, HRSG-12A and 12B mandatory inspections are carried out in every schedule outage of GT-7 and GT-8 by the Boiler Engineer, Mechanical Engineer and Plant Chemist.

The last inspection was performed in October 2020 and both HRSGs condition were found to be satisfactory.

Based on life assessment reports and routine maintenance inspections; we expect that with the current operating regime, *HRSG-12A and 12B may be operated reliably for the next 12-15 years.*

6.4.3. Module-4 Unit's Generators

6.4.3.1. GT-7 Unit Generator

Condition monitoring test of the Generator stator winding was carried out during the MOH of Feb-2015 by OEM (Alstom).

The following visual inspections and tests were performed for the stator;

- Visual Inspection for cleanliness and healthiness check of Overhang supports, Phase rings and leads, Generator terminals, Overhang insulation, Corona protection, Coil end-insulation / Insulating caps and stator core
- Boroscopic inspection of stator bars (4 NDE rings, 4 DE rings, 4 middle rings)
- Continuity and insulation resistance check of stator temperature probes
- Stator bar - core Alpha Coefficient measurement
- ELCID
- Slot wedging test
- Winding resistance measurement
- And for rotor;
- Visual Inspection of rotor after removing rotor retaining ring
- Insulation resistance measurement
- Winding resistance measurement
- RSO measurement

On the basis of tests, conductive paint activity on the stator winding was carried out during the outage in Feb-2017.

Generatortech flux probe was also installed to monitor Generator rotor healthiness during the outage in Sep 2015. Recent tests conducted in Jan 2021 and data collected from the Generatortech flux probe were analysed. The quality of the flux probe waveforms were observed to be excellent. Analysis of the complete dataset shows the previously detected turn short in Coil 1B has remained clear. The turn short in Coil 7B (first detected in December 2018) continues to be seen in the current test. When active, Coil 7B turn short would not be creating a measurable increase in rotor vibration and will not increase heating significantly.

Installation of PD sensors were completed in March 2019 during the outage. PD Data collected for Jan 2021 has been analysed and summarized with the conclusion "Stable (slight decrease) winding PD and low level". Hence PD test results show condition of Generator Stator **Good**.

The Generator rotor flux report and the PD test Jan 2021 indicate that there is no significant fault on the Generator Rotor and Stator and it can continue its normal operation and, hence Generator overall condition is **Satisfactory**.

Additionally, Full Stator Rewind (FSR) material is available onsite as strategic spare for GT-5, 6 and 7 to perform FSR as and when required.

We envisage that Unit-7 Generator can be operated for the next 10 years based on current operating data and strategic spares availability in KAPCO stores.

6.4.3.2. GT-8 Unit Generator

On the basis of conditioning monitoring tests, Full stator rewind (FSR) of the Generator was carried out in Oct / Nov-2015.

Generatortech flux probe was also installed to monitor the Generator rotor healthiness during the outage in October 2017.

Recent tests conducted in Jan 2021 and data collected from the Generatortech flux probe were analysed. The quality of the flux probe waveforms were observed to be excellent. Analysis of the

complete dataset shows that the previously detected turn short in Coil 7A turn short has remained clear and the Coil 6B short was constant in all loads that could have seen a turn short in the #6 coils. The highest recorded loads did not show the Coil 6B turn short, but they would not be expected to see a turn short in the #6 coils. When active, Coil 6B turn short would not be creating a measurable increase in rotor vibration and will not increase heating significantly.

Installation of PD sensors were completed in March 2019 during the outage. PD Data collected for Jan 2021 has been analysed and summarized with conclusion "Fluctuations in winding PD and Negligible level, normal voids". Hence PD test results show condition of Generator Stator **Good**.

Generator rotor flux report and PD test Jan 2021 indicates that there is no fault on Generator Rotor and Stator and, hence Generator overall condition is **Good**.

We expect that the newly rewound GT-8 Generator may be kept in operation reliably for next 20-25 years without any major concern.

6.4.3.3. STG-12 Unit Generator

On the basis of conditioning monitoring tests, Full stator rewind (FSR) of the Generator was carried out in Oct / Nov-2015.

Generatortech flux probe was also installed to monitor the Generator rotor healthiness during the outage in October 2017.

Recent tests conducted in Jan 2021 and data collected from the Generatortech flux probe have been analysed. The quality of the flux probe waveforms were observed to be excellent. "Analysis of the complete dataset shows the previously detected turn short in Coil 6A is still in effect. When active, Coil 6A turn short would not be creating a measurable increase in rotor vibration and will not increase heating significantly."

Installation of PD sensors was completed in March 2019 during the outage. PD Data collected for Jan 2021 has been analysed and summarized with conclusion "Stable winding PD and Low level. Voids in ground-wall insulation." Hence PD test results show condition of Generator Stator **Good**.

The Generator rotor flux report and PD test Jan 2021 indicates that there is no fault on the Generator Rotor and Stator and, hence, the Generator overall condition is **Good**.

We expect that the newly rewound STG-12 Generator may be kept in operation reliably for next 20-25 years without any major concern.

6.4.3.4. Summary for Remaining life of Module-4 Generators

Below is the summary for Remaining life of Module-4 Unit Generators in view of condition monitoring described in preceding paragraphs;

Table 6.18: Remaining life of Module-4 Generators

Units	COD	Make	Overall Condition Rating	Overall Generator Condition	Expected Remaining life (Years)
GT-7	19-01-1989	Alsthom	8	Satisfactory	10
GT-8	24-01-1989	Alsthom	9	Good	20*
STG-12	05-04-1995	Alsthom	9	Good	20*
*GT-8 and STG-12 Generator has undergone Full stator rewind (FSR) in 2015.					
Condition Rating Criteria 1-10:					
Rating 9-10 = Good; Rating 7-8 = Satisfactory; Rating 4-6 = Acceptable; Rating 1-3 = Unacceptable					

6.4.4. Module-4 Unit's Step-Up Transformer 7, 8 and 12

6.4.4.1. GT-7 Unit Transformer 7BAT01 Condition Monitoring

Transformer Oil analysis tests were performed in May 2020 by LABORELEC Belgium (Appendix-2 Unit-7 TF 7BAT01 Oil Analysis Report). Following is the conclusion from the oil analysis;

"The evolution of the dissolved gases can be considered as normal. There is no indication of thermal or electrical faults in the transformer.

The water content and relative saturation of the oil can be considered as normal. The properties that were investigated can be considered as normal.

The analysed winding paper ageing markers (furans, methanol) indicate beginning of paper ageing and the quality of winding paper can be assessed as still good (DP-value >600).

The next sample according to normal frequency. No other action needed."

All operating parameters of transformer e.g. Oil temperature, winding temperature are in normal range.

Thus, the overall condition of Unit-7 Step-Up transformer is Satisfactory; that is code-1 for healthy equipment operating normally.

6.4.4.2. GT-8 Unit Transformer 8BAT01 Condition Monitoring

Transformer Oil analysis tests were performed in May 2020 by M/S LABORELEC Belgium (Appendix-2 Unit-8 TF 8BAT01 Oil Analysis Report). Following is the conclusion from the oil analysis;

"The evolution of the dissolved gases can be considered as normal. There is no indication of thermal or electrical faults in the transformer. The properties that were investigated can be considered as normal.

The analysed winding paper ageing markers (furans, methanol) indicate no significant paper ageing and thus quality of winding paper can be assessed as very good (DP-value >800).

The next sample according to normal frequency. No other action needed."

All operating parameters of transformer e.g. Oil temperature, winding temperature are in normal range.

Thus, the overall condition of Unit-8 Step-Up transformer is **Satisfactory**; that is code-1 for healthy equipment operating normally.

6.4.4.3. STG-12 Unit Transformer 11CGEV001TR Condition Monitoring

Transformer Oil analysis tests were performed in May 2020 by M/S LABORELEC Belgium (Appendix-2 Unit-12 TF 12CGE V001TF Oil Analysis Report). Following is the conclusion from the oil analysis;

"The evolution of the dissolved gases can be considered as relatively stable and acceptable. This gas pattern indicates low temperature overheating (high load, insufficient cooling, ...) or stray gassing of the insulating oil. The water content and relative saturation of the oil can be considered as normal. The properties that were investigated can be considered as normal. The analysed winding paper ageing markers (furans, methanol) do not indicate any paper ageing and thus quality of winding paper can be assessed as very good (DP-value >800). The next sample according to normal frequency. No other action needed".

All operating parameters of transformer e.g. Oil temperature, winding temperature are in normal range.

Thus, the overall condition of Unit-12 Step Up transformer is **Satisfactory**; that is code-1 for healthy equipment operating normally.

6.4.4.4. Summary Module-4 Unit's Transformer Condition Monitoring

Depending upon above assessments and the recent tests conducted for condition monitoring of unit step-up transformers of Module-4 described in preceding section, healthiness is confirmed as per below summary table;

Table 6. 19: Overall Condition Assessment of Module-4 Unit Transformers

Unit	Unit Transformer	Overall Condition code	Overall Condition Status
GT-7	7BAT01	1	Satisfactory
GT-8	8BAT01	1	Satisfactory
STG-12	12CGEV001TR	1	Satisfactory
Condition Code 1: Healthy Equipment Operating Normally Condition Code 2: Early indication of operational fault. Frequency of test is increased (usually 6 months depending on the indicated problem) until either the condition worsens or until we are satisfied that the condition is not active and we would then push the testing interval out) No abnormality of Gas, Oil and Paper condition			

6.4.5. Control System of Module-4 Units

6.4.5.1. GT-7 and 8 Control System

The control system installed on GT-7 and 8 is GE Speedtronic Mark IV which is old yet operating satisfactorily. This Control system can be further operated reliably for the next 12 to 15 years with the availability of control system spares in KAPCO stores and spares obtained from control system replacement of GT-5 and 6.

6.4.5.2. STG-12 Control System

The control system at STG-12 is ALSTOM ALSPA Contrasteam V3 which was upgraded in 2011. The system is currently in production with a newer version. Spare parts have been maintained and support is available.

6.4.5.3. STG-12 Aux, HRSG-12A and 12B, and BOP Control System

The system supplied by ALSTOM (GE) is old but has operated satisfactorily since commissioning of the units. This Control system can be further operated reliably for next 12 to 15 years with the availability of control system spares in KAPCO stores. As an optimized strategy, spare parts removed from STG-11 control system replacement will also be used on STG-12.

6.4.5.4. Summary of Module-4 Units Control System

Below is the summary of remaining life of Module-4 Unit's Control system;

Table 6. 20: Remaining life of Module-4 Unit's control systems

Control System Module-4 GT-7, GT-8 & STG-12		
Unit	Control System	Expected Remaining Life (Years)
GT 7 & 8	GE Speedtronic Mark IV	10*
STG-12	Alstom ALSPA Contrasteam V3	11
STG-12 Aux, HRSG-12A & 12B, & BOP	Alstom T20 Micro Z	10**
*GT-7-8 control system may operate for next 10 years with availability of spares in KAPCO Stores and additional spares obtained from Control System replacement of GT-5-6		
**STG-12 control system may operate for next 10 years with availability of spares in KAPCO Stores and additional spares obtained from Control System replacement of STG-11.		

6.4.6. Cooling Tower System for STG-12 of Module-4

Cooling Tower structure visual inspections were performed and Concrete Corrosion was reported at different locations. Civil structure water proofing and repairs have been performed.

Tam Seal 10-F was applied which waterproofs and provides in-depth concrete protection. After applying the TAM sealing the cooling tower structure is observed "Good".

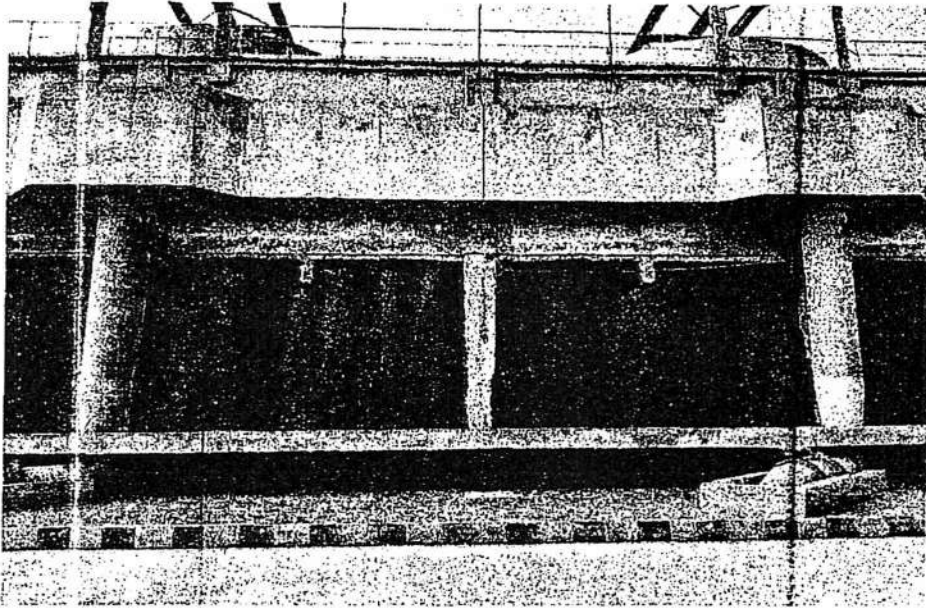


Figure 6. 3: Cooling Tower of STG-12

Cooling Tower fan, PMs (Preventive maintenance) are performed as per manufacturer recommended intervals. PMs records are available in the computer aided maintenance management system (Q4-CAMM). Mandatory spare parts inventory is maintained e.g. 1 refurbished gearbox for the cooling tower fan is available as spare.

Moreover, considering further 10 years operation beyond 2021, cooling tower fan blades and fill material may be needed to be replaced, if inspections decide this.

CW Piping inspection is carried out by KAPCO team during scheduled outages and piping condition is reported to be satisfactory.

Cooling Tower Fans and CW Pumps were inspected during the last schedule outage in Feb-March 2021 and no abnormality was reported.

As per above inspections and current condition monitoring it is envisaged that the Cooling Tower System can be operated reliably for the next 12 years.

6.5. Module-5 Plant Components' Residual Life Assessment

6.5.1. Gas Turbine Unit 13, 14 and Steam Turbine Unit-15

Gas Turbine GT-13 and GT-14: Hot gas path components e.g. Turbine blades/vanes, Combustion chamber bricks, nozzles, etc. are being replaced periodically on MOH and CI as per recommended EOH intervals by the OEM (Siemens). One complete set of turbine blades and vanes is always available in KAPCO stores as a strategic spare.

GT-13 and 14 Si3D blades up-gradation was performed in the Outage Sep 2011 for the 1st two stages of the turbine (keeping last 2 stages the same). Installation of Siemens (innovative 3-dimensional) Si3D blades with new Nickel based material, improved cooling air path and optimized aerodynamic aerofoil design improved the Units' performance.

Last Major Overhauling (MOH) was conducted in Sep-October 2019. Turbine blades/vanes were replaced as per recommended EOH.

GT-13 and 14 compressor vanes were replaced with new ones in 2010 and 2013 respectively.

The compressor blades have been in service since commissioning. During visual inspections and NDTs performed in the MOH 2019, no findings were reported and the condition of the compressor blades was found to be satisfactory. In the event some findings appear in the next MOH, the compressor blades are recommended to be replaced.

Air Intake filters are to be replaced in 2021.

Following NDTs were performed in the MOH 2019 for condition assessment of Gas Turbine parts after dismantling;

- Ultrasonic Testing
- Magnetic Particle Test
- Dye Penetrant Test
- Hardness Test

The scope of the visual inspection and extended NDTs for LTE included;

- Ultrasonic Testing of Compressor bearing, Turbine bearing, Gas Burner, Mixing Chamber Casing, Inner casing, Compressor Discs, Turbine Discs, Tie Rod, Intermediate shaft, Front, centre and rear hollow shaft, Burner carrier, Premix Burner, Combustion chamber shell, dome, Fuel Oil piping, cooling air-line, Blow off air-line, Fuel Gas piping etc.
- Magnetic Particle Test of Compressor vane carrier, Compressor vanes, Compressor blades, Combustion chamber shell, Compressor and Turbine wheel discs, Intermediate shaft, Front, centre and rear hollow shaft, Tie-rod, Compressor and Turbine vane carriers, etc.
- Dye Penetrant Test was performed for Compressor and Turbine bearing, Burner Gas Distributor, Mixing chamber of combustion chambers, Inner Casing, Tie-rod, Exhaust casing liner, Turbine exhaust diffuser, Fuel Oil piping, cooling airline, Blow off airline, Fuel Gas piping etc.
- Hardness Test for Centre Casing and Front Hollow shaft

The overall NDT results were categorized as acceptable except for a few minor observations which were addressed in the MOH 2019 activities e.g. indications on Mixing casing and Exhaust casing liner which were ground out and rewelding work performed as corrective measure etc.

The overall condition of both units Gas Turbine-13 and 14 observed "Good" during visual inspections and NDTs performed in last MOH Sep-Oct 2019 and recent schedule outages.

Steam Turbine STG-15 last major overhauling was performed from Feb to April 2010. During the MOH visual inspections and NDTs, Turbine HP/LP rotor and casings were found in good condition except for a few minor indications which were attended as a part of the MOH activities.

Afterwards, Minor Overhauling inspection has been performed in Oct 2016.

Following NDE techniques were applied by the Siemens' NDE Specialist;

- Ultrasonic Testing
- Dye Penetrant Test

Scope of visual inspection and NDEs included;

- Ultrasonic Testing of turbine bearings, bearing pads, and turbine foundation bolts
- Dye Penetrant Test of turbine bearings, bearing pads, Steam Turbine Emergency Stop Valve, Control Valve, HP Bypass valve, turbine casing drain valves etc.

Overall NDT results were categorized as acceptable except for a few minor observations on the HP Bypass control valve spindle but it was categorized as useable. Also, the Steam turbine casing drain valve cone was replaced as per Dye Penetrant Test indication.

Boroscopy inspection of the HP and LP steam turbine Last Stages and Cross over pipe were performed by Siemens' Engineers. During the Boroscopy inspections no abnormality was observed.

The overall condition of Steam Turbine Unit-15 and condenser is reported as "Good" in visual inspections and NDTs performed during the outages in 2010 to 2016.

STG-15 HP Steam stop and control valve actuators were overhauled during the GT-13 and 14 MOH in 2019.

Following is the expected Remaining Life Assessment summary of Module-5 Units as per the Units' condition assessment and operating regime;

Table 6.21: Remaining Life of Module-5 Units

Unit #	Operating Hours in Design Life of 30 years	Operating Hours in Extended Design Life of 40 years*	KAPCO Operating Hours COD to Mar-2021	Remaining Operating Hours In Extended Design Life of 40 years	Remaining Design life (Years)
GT-13	240,000	320,00	176,245	143755	18
GT-14	240,000	320,00	170,947	149053	19
STG-15	240,000	320,00	179,741	140259	18

Module-5 Units are expected to operate for minimum further 10 years without any major concern.

*CCGT Operating Life expectancy before retirement is 40 years (320,000 hours based on 8,000 operating hours/year) ref section 5.3.4 and 5.4 of this document.

6.5.2. Module-5 HRSG 13 and 14

HRSG-13 and 14 complete inspection and remaining life assessment was carried out from Sep-Oct 2019 by SGS, Pakistan (Appendix-1: Remaining Life Assessment HRSG-13 and 14).

During inspections relating to life assessment for HRSG-13 and 14 no significant deterioration was reported except a few recommendations of improvement which have been addressed e.g.

Recommendation for HRSG-13 Sulphur deposition should be cleaned/washed out from tube fins to optimize efficiency, HRSG-13 and 14 are washed keeping in view the increased stack temperature, which indicates washing is required, as per recommendation. Observed cracks in the cyclone drum (LP Drum) were welded for both HRSG-13 and 14 and recommended to keep monitoring in every following outage.

Scope of work for complete inspection and remaining life assessment of HRSG-13 and 14 included the following inspections and NDTs;

- Visual inspection of HP and LP drums, tubes, headers, for localized and uniform corrosion, deposits, erosion, pitting etc.
- Visual inspection of economizer regarding fins condition
- Visual inspection of protective coating/insulation for damages
- Visual inspection regarding internal corrosion and pitting including evaluation of pitting / corrosion for fitness
- Visual inspection of all structural steel parts including ducts, platforms, handrails and structural steel supports for ducts/piping for any visual defects.
- Visual inspection of tube bends and headers
- Visual inspection and DPT of steam header pipe welds for cracks
- Visual inspection of all accessible weld joints of HP Drum/LP separator, like shell, heads and nozzles.
- Hardness testing of HP drum, LP drum tubes and headers, 28 location from tubes, 2 from each header, 4 locations from inside the drums.
- Ultrasonic flaw detection of suspected weld joints of HP drum, LP drum.
- MPI/DPT of selected weld joints
- Metallographic testing of boiler pressure parts like 3 from each drum, one from each header to study the metallurgical changes, degradation and evaluation for its fitness for service.
- Ultrasonic thickness gauging of HP drum, headers, tubes, soot blowers, as per ASME codes to find out overall view of current metal condition for fitness.

No major anomalies were observed in the microstructure of pressure parts observed through Reflected Light Microscopy.

Remaining Life of HRSG-13 and 14 was calculated for the available data, comparing each component's thickness at installation and the current thickness gauging in 2019, then using the remaining corrosion allowance to assess remaining life. Major components' life was calculated greater than 30 years for HRSG-13 and 20 years for HRSG-14.

On the basis of above inspections, it was concluded that HRSG 13 and 14 is in satisfactory condition as tube modules, HP and LP drums and Header NDT inspection resulted in no major deficiency.

Also, HRSG-13 and 14 mandatory inspections are also carried out in scheduled outages of GT-13 and GT-14 by the Boiler Engineer, Mechanical Engineer and Plant Chemist.

Both HRSGs condition was found satisfactory during an inspection performed in Feb 2021.

Based on the life assessment report which revealed no significant deterioration and routine maintenance inspections; we expect that with the current operating regime, **HRSG-13 and 14 may be operated reliably for the next 10-15 years.**

6.5.3. Module-5 Units' Generators

Following are the technical Specifications for Module-5 Units' Generators;

Table 6.22: Technical Specifications of Module-5 Units' Generators

Technical Specifications	GT-13-14	STG-15
Type	TLRI 108/36	TLRI 108/41
Rated Power Capacity	170 MVA	175 MVA
Rated Voltage (L-L)	11 KV $\pm 10\%$	11 KV $\pm 10\%$
Phases	3 ϕ ; YY.	3 ϕ ; YY.
Rated Output Current	8923A	9185A
Speed	3000Rpm	3000Rpm
Frequency	50HZ	50HZ
Power Factor	0.85	0.85
Gen Cooling System	Air Cooled	Air Cooled
Cold air temp	40°C	40°C
Make	Siemens Germany	Siemens Germany

6.5.3.1. GT-13 and GT-14 Unit Generators

Condition monitoring tests of GT-13 and 14 Generators were carried out during the Minor Overhauling in Sep-Oct 2019 in the presence of the OEM's Inspection Engineers (Siemens).

Following Visual inspections and tests were performed for the stator;

- Visual inspection for cleanliness and healthiness check of stator, TE and EE end windings, cooler enclosure etc.
- Insulation resistance test
- Winding resistance measurement and for rotor;
- Boroscopic Inspection of rotor
- Insulation resistance measurement
- Winding resistance measurement

All stator and rotor test results are reported satisfactory except for a few minor observations of cleanliness which has been attended. A visual inspection of the Generator cooler and cooler enclosure was performed, no sign of water leakage was noticed in the cooler, piping, water boxes and flanges. Checking of the J-strips, slip rings, grounding system was performed and found normal.

Routine offload, on load, test results are showing healthy condition for both Generators. Overall condition of Generators is considered "Good".

Based on the MOH test results, routine condition monitoring tests and operating conditions, *we envisage that Unit-13 and 14 Generators can be operated reliably for the next 10-12 years.*

6.5.3.2. STG-15 Unit Generator

Medium overhauling of STG-15 Generator was carried out in Sep-Oct 2019. Condition monitoring tests of the Generator and visual/NDT inspections were carried out in the presence of the OEM's Engineers (Siemens).

NDT (PT) of rotor fan blades (TE & EE) was done by Siemens' Inspection Engineers and no finding was observed.

Checking was carried out for J-strips, slip rings, grounding system, generator cooling circuit and coolers etc which were found to be normal.

The following electrical tests of the Generator Stator / Rotor were carried out.

- Insulation resistance of stator.
- Loop resistance of stator.
- Insulation resistance of rotor.
- Loop resistance of rotor.

All test results are observed satisfactory with no findings reported. Routine offload, on load, test results are showing its healthy condition. Overall condition of the Generator is considered "Good".

Based on MOH test results, routine condition monitoring tests and operating conditions, we envisage that Unit-15 Generator can be operated reliably for next 12-15 years.

6.5.3.3. Summary for Remaining life of Module-5 Generators

Below is the summary for remaining life of Module-5 Unit Generators in view of condition monitoring described in preceding paragraphs and operating conditions;

Table 6.23: Remaining life of Module-5 Generators

Units	COD	Make	Overall Condition Rating	Overall Generator Condition	Expected Remaining life (Years)
GT-13	10-12-1994	Siemens	9	Good	10-12
GT-14	19-10-1994	Siemens	9	Good	10-12
STG-15	09-10-1996	Siemens	9	Good	12-15
Condition Rating Criteria 1-10: Rating 9-10 = Good; Rating 7-8 = Satisfactory; Rating 4-6 = Acceptable; Rating 1-3 = Unacceptable					

6.5.4. Module-5 Unit's Step-Up Transformer 13, 14 and 15

Following are the technical Specifications for Module-5 Units' Transformers

Table 6.24: technical specifications of Module-5 Transformers

Technical Specifications	GT-13-14	STG-15
Make	TRAFO UNION	TRAFO UNION
Rated Power (MVA)	168	190
Rated Voltage KV (LV/HV)	11 / 258	11 / 258
Rated Frequency (HZ)	50	50
No of Phases	3	3
Rated Current (A) LV/HV	8819/422	8083/661
Type of Cooling	ONAN/ONAF	ONAN/ ONAF
Temp. Rise Winding/Oil	55/50 °C	55/50 °C

6.5.4.1. GT-13 and 14 and STG-15 Unit Transformers 13BAT01, 14BAT01 and 15BAT01 Condition Monitoring

During the Outage in Sep-Oct 2019, for all 03 Unit Transformers 13BAT01, 14BAT01 and 15BAT01, the following Electrical tests were executed by 3rd party Avotech Engg Services.

- a) Insulation Resistance,
- b) Turn Ratio,
- c) Excitation Current,
- d) SFRA and
- e) Magnetic Balance.
- f) Short Circuit Impedance
- g) Winding Resistance Tests
- h) Oil Tests carried out: DGA , Oil Break down Voltage test, Moisture test, Oil Acidity, Interfacial Tension, Corrosive sulphur, Furan Analysis test.

The test results reported no abnormality on any of three Unit transformers.

Transformer Oil analysis tests has been performed in May 2020 by LABORELEC Belgium (Appendix-2 Unit-13 TF 13BAT01, Unit-14 TF 14BAT01 and Unit-15 TF 15BAT01 Oil Analysis Report).

Following is the conclusion from oil analysis report for all three Transformers; "The evolution of the dissolved gases can be considered as normal. There is no indication of thermal or electrical faults in the transformer. The water content and relative saturation of the oil can be considered as normal."

All operating parameters of transformers e.g. Oil temperature, winding temperature are in normal range.

Thus, the overall condition of Unit-13, Unit-14 and Unit-15 Step-Up transformers is "Good"; and designated code-1 is for healthy equipment operating normally.

6.5.4.2. Summary of Module-5 Unit Transformers Condition Monitoring

Depending upon above assessments and the recent tests conducted for condition monitoring of unit step up transformers of Module-5 described in preceding section, healthiness is confirmed as per below summary table;

Table 6.25: Overall Condition Assessment of Module-5 Unit Transformers

Unit	Unit Transformer	Overall Condition code	Overall Condition Status
GT-13	13BAT01	1	Good
GT-14	14BAT01	1	Good
STG-15	15BAT01	1	Good
Condition Code 1: Healthy Equipment Operating Normally Condition Code 2: Early indication of operational fault. Frequency of test is increased (usually 6 months depending on the indicated problem) until either the condition worsens or until we are satisfied that the condition is not active and we would then push the testing interval out) No abnormality of Gas, Oil and Paper condition			

6.5.5. Control System of Module-5 Units

6.5.5.1. GT-13 and 14 Control System

The GT-13 and 14 old Siemens TELEPERM ME Control system, operating since commissioning, was replaced with a state-of-the-art Siemens SPPA T3000 system in March 2021, which has enhanced the system integrity. Thus, the newly installed control system can be expected to operate reliably for the next 20 years.

6.5.5.2. STG-15 Control System

The STG-15 old control system was replaced with a state-of-the-art new control system (Siemens SPPA T3000) in Feb 2015. Its remaining life is expected to be about 15 years.

6.5.5.3. STG-15 Aux, HRSG13 and 14, and BOP Control System

The old Siemens TELEPERM ME Control system, operating since commissioning, was replaced with a state-of-the-art Siemens SPPA T3000 in March 2021, which has enhanced the system integrity. Thus, the newly installed control system can be expected to operate reliably for the next 20 years.

6.5.5.4. Summary of Module-5 Units Control System

Below is the summary of remaining life of Module-5 unit's control system;

Table 6.26: Remaining life of Module-5 unit's control systems

Control System Module-5 GT-13, GT-14 & STG-15 Remaining Life

Unit	Control System	Expected Remaining Life (Years)
GT 13 & 14	Siemens SPPA T3000	20
STG-15	Siemens SPPA T3000	15
STG-15 Aux, HRSG-12A & B, & BOP	Siemens SPPA T3000	20

6.5.6. Cooling Tower System for STG-15 of Module-5

Cooling Tower structure visual inspections were performed during the last scheduled outages. Concrete Corrosion was observed at different locations. Civil structure water proofing and repairs were performed.

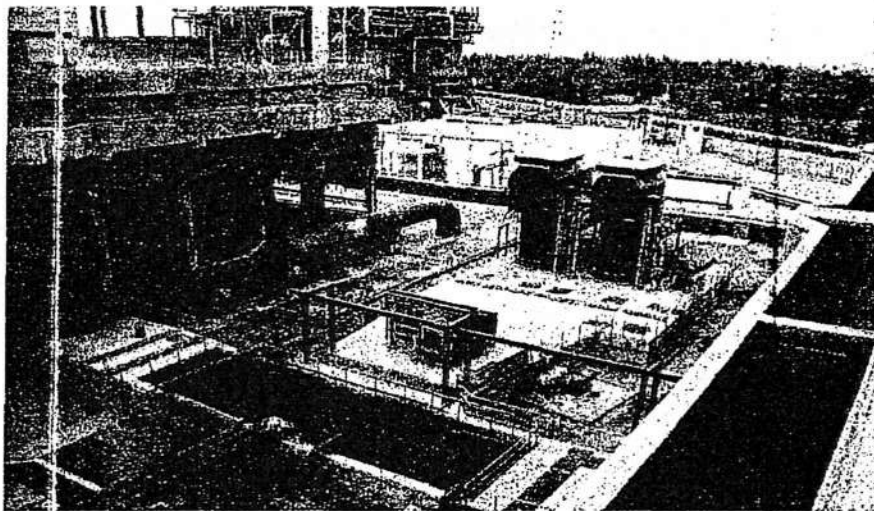


Figure 6. 4: Cooling Tower System STG-15

Tam Seal was applied which waterproofs and provides in-depth concrete protection. After applying the TAM sealing cooling tower structure is observed **good**.

Inspection of the CW Supply and return lines revealed that the internal coating is in **satisfactory** condition. Epoxy coating of both CW Pumps Bell housing, Impellers, Start-up filling pump has been carried out and overall condition **good** is observed.

Epoxy Paint coating is carried out on cooling Tower Risers, Headers and Piping and thus **good** condition is maintained;



Figure 6. 5: Circulating Water (CW) Pumps STG-15 for Cooling Tower

Cooling Tower fan, PMs (Preventive maintenance) are performed as per manufacturer recommended intervals. PMs records are available in the computer aided maintenance management system (Q4-CAMM). Mandatory spare parts inventory is maintained e.g. 2 refurbished gearboxes for the cooling tower fans are available as strategic spare (See Appendix-6 Strategic Spares List-Block-3).

As per above inspections and detailed condition monitoring, it is envisaged that the Cooling Tower System can be operated reliably for next 12 years.

6.5.7. Water treatment plant Block-3 Module-5

Water Treatment plant routine preventive maintenance is conducted on schedule and, therefore, is maintained in healthy conditions. The water treatment plant and auxiliaries are reported to be operating without any trouble. As per current excellent maintenance techniques applied and good operating conditions, it is envisaged that the Water Treatment Plant can be operated reliably for the next 12-15 years.

6.6. Buildings and Civil Structure Integrity Assessment

Civil structure integrity life assessment has been conducted by company, Inspect Test, (See Appendix-3 Building and Civil Structure Integrity Assessment).

Following buildings and structures were covered in above work scope;

- Administration Building
- Gas Turbine Buildings 1-2, 3-4, 5-6, 7-8, 13-14
- Steam Turbine Buildings 9-10, 11-12, and 15
- Cooling Tower unit 9, 10, 11, 12 and 15
- Clarifier 9-10, 11-12 and 15
- Water Treatment Building B-I, B-II and B-III

- Black Start Diesel Engine Building
- Central Control Room Building CCR-1, 2, 3

Scope of work included visual inspections and NDTs as outlined below;

- Visual inspections of all buildings and civil structure for corrosion,
- Identification of points of main load bearing areas of civil structure
- Identification cracks in the main structure
- Complete structure analysis of all damaged areas
- Concrete compressive strength measurement by Rebound Hammer / Compressive Strength Test.
- Crack Depth Measurement by Ultrasonic Pulse Velocity Test and ultrasonic method.

The following observations and recommendations were made;

- Number of horizontal, vertical and critical shear cracks were found which are to be repaired as per recommended procedure.
- All Damaged, rusted and Exposed Steel rebar to be repaired by the recommended procedure.
- Cooling tower and clarifier buildings should be repaired as rusted steel rebar were found and it is recommended that these buildings should be properly coated for water proofing and inspected periodically.
- Water Treatment / Pre-Treatment / Demin Plants were found in impaired condition. It is recommended that these buildings must apply acid resistance flooring with Epoxy Novolac which is ideal for harsh chemical and solvent resistant applications.
- Control of Water Treatment / Pre-Treatment / Demin Plants buildings impairment by avoiding leakage and accumulation of chemicals.
- Water seepage should be controlled as it may weaken the structure over time, by rusting the steel rebar. This can be done by applying a water-proof coating.
- It was advised that all repairs should be performed by recommended procedures.

Keeping in view above recommendations, civil structures and buildings have been repaired, or are in the process, as per suggested procedure. Overall Condition of civil structures and buildings is observed Satisfactory.

Power station buildings and structures are designed to have a minimum life of 50 years for general building design code compliance.

Keeping in view the current condition of buildings and structure we envisage remaining useful life 15-20 years with on-going checks and necessary repairs as and when needed.

7. OPERATIONS AND MAINTENANCE PRACTICES

7.1. Process Safety Management Systems

KAPCO Management has well established Local Procedures and Rules for Safety Management covering the below aspects;

1. KAPCO Safety Rules
2. Incidents Preparedness Reporting Response Investigation
3. Electrical Safety Procedure
4. Overhead Travelling cranes hoists and other lifting-devices
5. General Confined Spaces
6. Hot Work Procedure
7. Safety Documents Procedure
8. Health and Safety Hazards identifications and-Risk Assessment
9. LV and MV Apparatus
10. Plant Emergency Shutdown
11. Working at height
12. Behaviour Based Safety Fresh-Eyes
13. High Voltage Apparatus
14. etc.

And for Chemical Control and Environment management the following Local Procedures are developed and are being followed;

1. Guidelines and rules for management of bulk chemicals
2. Air Emission control procedure
3. Effluent Water Control Procedure
4. Solid Waste Management Procedure
5. Environment Aspects Identification Procedure
6. etc.

7.2. Maintenance Management System

Operations and Maintenance activities are being planned, controlled and executed using Computerized Maintenance Management System Q4CMM of Engica UK.

All Preventive Maintenance, Condition based Maintenance and Corrective Maintenance is managed through CMMS (Q4CMM).

All Plant Equipment Preventive Maintenance work orders are raised as per set frequency i.e. Monthly, 3 Monthly, Yearly etc. according to OEM recommendations for the relevant section and are executed well in time in an effective and efficient manner.

The Work Orders are serially pre-numbered in the system and classified as under;

- Fault Work Order

Represents only those work orders relating to breakdown / failure of any equipment and/or system leading to loss of generation, efficiency, safety and/or adverse impact to the environment.

► **Ad-hoc Work Order**

Ad-hoc work order represents all those activities that relate to general services required, non-critical jobs and are not covered under Fault and PM work orders.

► **PM Work Order**

PM work orders are those that represent preventive maintenance activities only.

Operations Team initiates work order Fault or Adhoc in view of breakdown/failure of any equipment and improvement work required at the Plant. That work is planned and executed by the Maintenance Team in accordance to set Priority of work order to avoid Generation and Plant Performance Loss.

After completion of work, the Maintenance Team closes the work order recording.

- Effort (personnel) and Work Duration (hours) as man-hours
- Work undertaken in work done field

Some work orders are specialized e.g. SIMs, TILs, Risk Matrix and Plant Modifications as defined below;

Safety Information Memorandum (SIM) based work orders are raised to improve the conditions that caused the incidents.

Technical Information Letter (TIL) based work orders reflect a desired knowledge enhancement approach including safety and plant integrity as these relate to specialized information about the Units received from the OEM.

Risk Matrix is a periodic assessment of each section's equipment to determine criticality on the basis of being obsolete, health, life assessment, non-availability of spares and/or back-up, etc. In CAMM PMs are developed to initiate monthly Risk Matrices review.

Plant Modification means;

- A change in Reference Design datum, geometry, or materials; or
- Permanent change of setting, modes of operation, components in a control, interlock or protection system (which may include computer software); or
- The addition or permanent removal of components in a system or a complete system whereby a 'system' or 'component' includes plant, electrical apparatus, or load bearing structure or any combination of these.

All specialized Work Orders SIMs, TILs, Risk Matrix and Plant Modifications are raised by the Planning section. After completion of work all specialized Work Orders are closed by the Sectional head only.

7.3. Integrated Management System

Since July 2004, KAPCO has been compliant with the following accreditations to the Integrated Management System:

ISO 9001:2015 Quality Management System

ISO 14001:2015 Environmental Management System

OHSAS 18001:2007 Occupational Health and Safety Assessment Series (Occupational Health and Safety Management System)

7.4. Environment Management System

KAPCO has developed well established Policy Guidelines and Procedures for Environment Management system.

KAPCO is accredited and complying standard ISO 14001:2015 Environmental Management System.

Environment Performance Monitoring is being conducted on regular basis by EPA Certified Independent Consultant, in compliance with Pakistan Environment Protection Act (1997) and Punjab Environment Protection Agency standards.

Environment Monitoring at KAPCO Complex includes, monitoring of Air, Water and Noise Emissions generated from Operations of Gas Turbines, Steam Turbines, Boilers, Fuel Oil Treatment Plants etc.

Samples of Air emissions are taken at the stack of HRSGs and Boilers for checking NO_x, SO_x, and CO emissions in flue gases being disposed to the Environment.

Noise checking is conducted inside and outside the Plant boundary at different points.

Quality of waste-water being disposed is checked at the point of generation source and is controlled for disposal in compliance to Punjab EPA standards.

For Solid waste management collection and segregation is done for hazardous and non-hazardous waste. Hazardous waste stored in the Toxic/hazardous storage area is disposed off through

EPA approved contractor for final incineration.

Recent Report submitted to Punjab Environment Protection Agency (PEPA) as per statutory requirements is found in compliance, attached as Appendix-4 Environmental Compliance Report

All emissions relating to air, water and noise are well within limits set by Punjab Environment Quality Standards.

Ambient Air quality measured at 1.2 Km from Plant site is observed well within Air Quality Standard of PEPA.

In acknowledgement to accomplishment achieved for Environment protection, KAPCO has been awarded in 2020, Certificate of Appreciation from National Forum for Environment and Health.

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7.5. Historic Major Modification Summary

Major Upgrades and Improvement Projects relating to Generation units, Environment and Health and Safety are documented as Appendix-5 Historic Major Modification Summary.

7.6. Spares Management

KAPCO has maintained adequate spares inventory for all generating units to ensure maximum Plant Availability and to reduce Unit down times.

Stock management is ensured through the Computerized Stock Management System Q4-Stock of Engica UK.

Each spare part is given a stock number, stock description, owning team, Re-Order Level and Re-Order quantity in the Computerized Stock Management System. When a spare part reaches Re-order level, the procurement process is initiated.

Above 30,000 spare parts are stored in the KAPCO Stores for the Gas Turbines, Steam Turbines and Auxiliaries relating to Mechanical, Instrument and Electrical Equipment.

List of Strategic spares is documented as Appendix-6 Strategic Spares List.

It is concluded that the large volume of spares inventory at KAPCO Complex is more than adequate for reliable operation of the KAPCO Plant to achieve maximum Plant Availability in coming years.

8. CONCLUSION AND RECOMMENDATIONS

The study has been conducted to assess the residual useful life of the KAPCO Plant main mechanical, civil, electrical and control equipment based on design criteria, current operating parameters, design and current performance, upgrades and major replacements, operation procedures and maintenance practices, major outage inspection reports, life assessment reports and condition monitoring test reports.

Each of the Module's 1-5 major equipment condition has been categorized as Good, Satisfactory or Acceptable.

Operating life before retirement of CCGTs has been observed 40-50 years around the World. This study has assumed a 40-year extended operating life based on a nominal 8,000 operating hours per year, which equates to lifetime operating hours of 320,000. The operating hours of the Units at KAPCO range between 94,000 to 180,000 indicating that the remaining life of the KAPCO units could be in the range 17 – 28 years, thus demonstrating that a life extension of 10 years being considered by KAPCO should be achievable with resulting good reliability and performance.

Significant inventory of strategic and mandatory spares has been maintained by KAPCO as per next 10 years operating plan which is of great sustenance in achieving the expected Remaining plant life.

Currently well-established policies and procedures are intact for Safety, Environment and Maintenance Management system along with implementation of Integrated management system which shall ensure safe and reliable operations of Plant for coming years as well.

Based on this qualitative and analytical study, module wise residual life assessment has been concluded as below;

- a) **Module-1 (GT-1, GT-3 and STG-9)** plant is in overall **Satisfactory** condition and expected Remaining life is assessed to be a minimum **10 years** maintaining current best O&M practices and conducting mandatory upgrades, repairs/replacement as recommended time to time by OEM in major outages.

Plant load (MW), has been well maintained since IDC 1996. Average plant availability of last 5 years is above 85% which is excellent.

GT-1 Generator is in Good condition while GT-3 and STG-9 Generator condition is Satisfactory with expected Remaining life of 10 years.

The condition of Unit Transformers has been found to be 'Satisfactory to Acceptable'.

Cooling Tower and Water Treatment system is in satisfactory condition and can be operated reliably for next 10 years.

The following repairs/replacements/upgrades are recommended for Module-1 Units in the next MOH;

- i. GT-1-3 replacement air intake filters when Differential pressure approaches upper limit
- ii. STG-9 replacement of Row-1 blades
- iii. HRS-1-3 Insulation and Cladding to be replaced from deteriorated surfaces.

- iv. Cooling Tower structure inspections and repair with Tam Seal at portions showing corrosion effect.

- b) **Module-2** (GT-2, GT-4 and STG-10) plant is in overall **Satisfactory to Acceptable** condition and expected Remaining life is assessed to be a minimum **10** years maintaining current best O&M practices and conducting mandatory upgrades, repairs/replacement as recommended time to time by OEM in major outages.

Plant Load and other operating parameters are well maintained since IDC 1996. Average plant availability of last 5 years is above 86% which is excellent.

GT-2 and GT-4 Generator are in **Satisfactory** condition while STG-10 Generator condition is **Good** with expected Remaining life of 10-12 years.

The condition of Unit Transformers has been found to be **Satisfactory** for module-2 units.

The following repairs/replacements/upgrades are recommended for Module-2 Units in the next MOH;

- i. GT-2 and GT-4 replace air intake filters when Differential pressure approaches upper limit
 - ii. STG 10 replacement of Cooling Tower Fill material.
- c) **Module-3** (GT-5, GT-6 and STG-11) plant is in overall **Good** condition and expected Remaining life is assessed to be a minimum of **10** years maintaining current best O&M practices and conducting mandatory upgrades, repairs/replacements as recommended in major outages.

Plant load and other Performance indicators are well maintained since IDC. Hot Gas Path Up-gradation has been conducted to maintain ADC load. Average plant availability of last 5 years is 84%, which is good.

GT-5 and GT-6 Generators are in **Satisfactory** condition. STG-11 Generator is newly rewound and its overall condition is **Good**. Expected remaining life of the Generators is assessed to be above 10 years for GT-5 and 6 and around 20 years for STG-11.

The condition of Unit Transformers for all module-3 Units' is **Satisfactory**. GT-5 and GT-6 control systems have been replaced with new GE Mark VI.

Cooling Tower and Water Treatment systems are in **Satisfactory** condition and can be operated reliably for next 12 years with routine Preventive maintenance schedules.

The following repairs/replacements/upgrades are recommended for Module-3 Units in the next Major Outages;

- i. HRSG 11 A-B Flue Gases Ducts renovation due to aging factor, availing each shutdown opportunity
- ii. STG-11 replacement of cooling tower fan blades.

- d) **Module-4** (GT-7, GT-8 and STG-12) plant is in overall **Satisfactory to Good** condition and expected Remaining life is assessed to be a minimum **10** years maintaining current best O&M practices.

Plant Load and other operating parameters are well maintained since IDC. Gas Turbines Hot Gas Path Up-gradation has been conducted to maintain ADC load. Average plant availability of last 5 years is around 85% which is excellent.

GT-7 Generator is in **Satisfactory** condition with expected remaining life of above 10 years. GT-8 and STG-12 Generators are newly rewound and their overall condition is **Good**. GT-8 and STG-12 expected remaining life is excess of 20 years.

The condition of Unit Transformers for all module-4 Units' is **Satisfactory**.

The following repairs/replacements/upgrades are recommended for Module-4 Units in the next Major Outages;

- i. GT-7 recommendation by OEM to replace compressor aft brush seals and honey-comb seals in next major inspections for better performance.
- ii. STG-12 replacement of cooling tower fan blades and fill material.

- e) **Module-5** (GT-13, GT-14 and STG-15): This is the highest efficiency CCGT plant not only in KAPCO Complex but all over the Pakistan which can operate on 3 types of fuel e.g. LSFO, Natural Gas and HSD. Plant is in overall **Satisfactory to Good** condition and expected remaining design life is assessed to be a minimum **10** years maintaining current best O&M practices and conducting mandatory upgrades/repairs/replacement as recommended.

Plant has always demonstrated higher loading capacity than IDC due to excellent maintenance strategy. Gas Turbines have undergone turbine blades Si3d Up-gradation. Control system has been replaced recently with state-of-the-art Siemens SPPA-T3000. Average plant availability of last 5 years is 84%, which is good.

GT-13, 14 and STG-15 Generators and Unit Transformers overall condition is considered **Good** that is healthy equipment operating normally. Expected Remaining useful life is assessed 12-15 years.

Cooling Tower system and Water Treatment Plant is in **Satisfactory** condition and can be operated reliably for next 12 years with routine preventive and corrective maintenance

The following repairs/replacements/upgrades are recommended for Module-5 Units in the next Major Outages;

- i. Replacement of compressor blades for GT-13 and 14 (No finding reported till date)

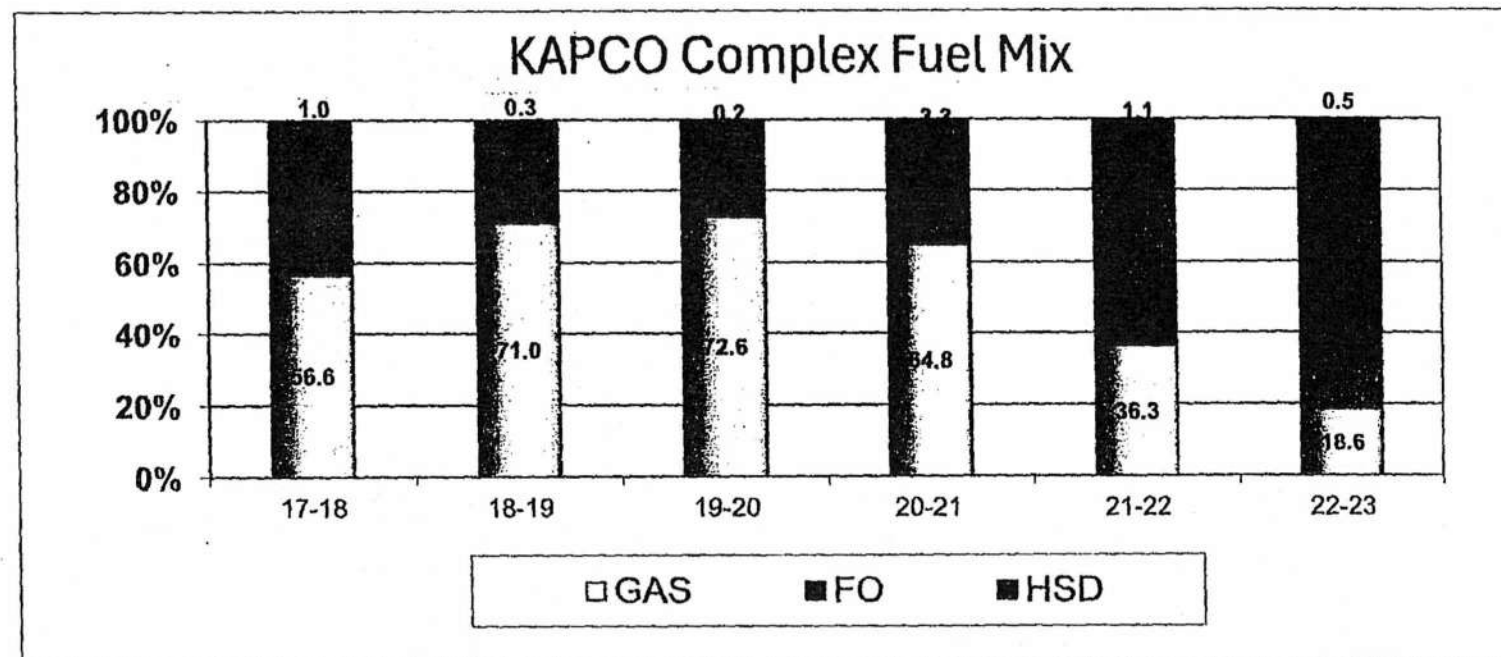
- ii. GT-13-14 Corrosion Prevention Painting of filter house at external surface.
 - iii. Repair of concrete structure of Cooling Tower and Clarifiers of STG-15
 - iv. Renovation of Thermal Insulation of GT-13 and 14 and HRSG-13 and 14.
- f) **All Civil buildings and structures** integrity assessment has been carried out which has indicated overall condition to be **Satisfactory**, except some minor cracks and concrete corrosion at various sections e.g. cooling tower concrete corrosion. Recommendations of this integrity assessment must be adhered for safe and reliable operation of plant.

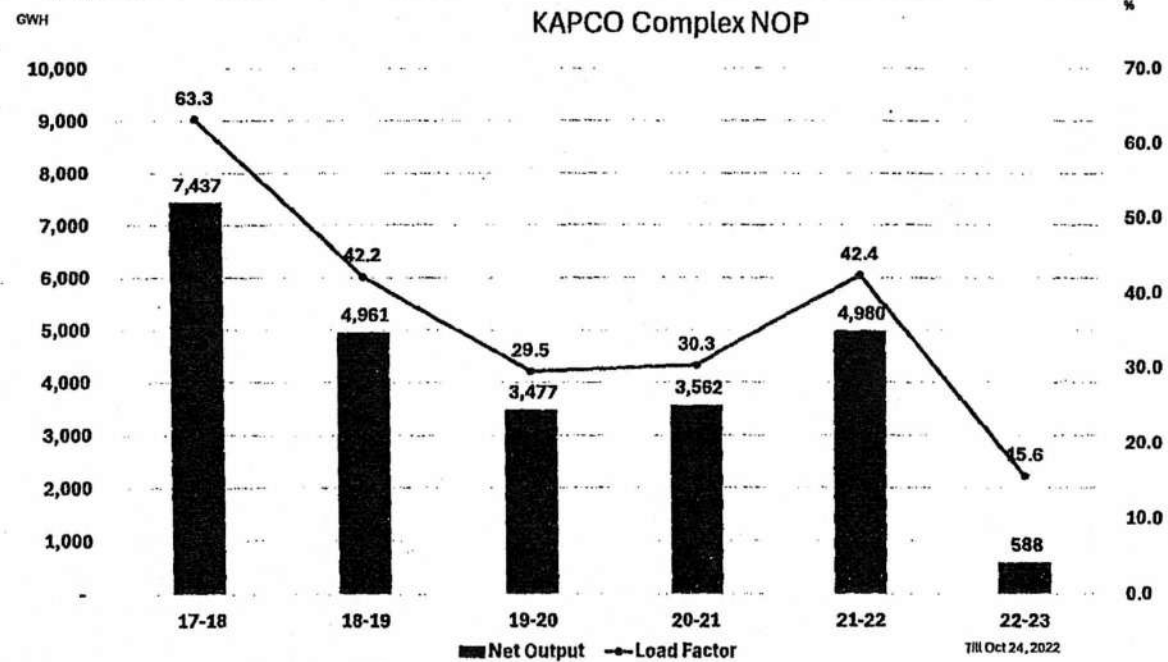
Appendices

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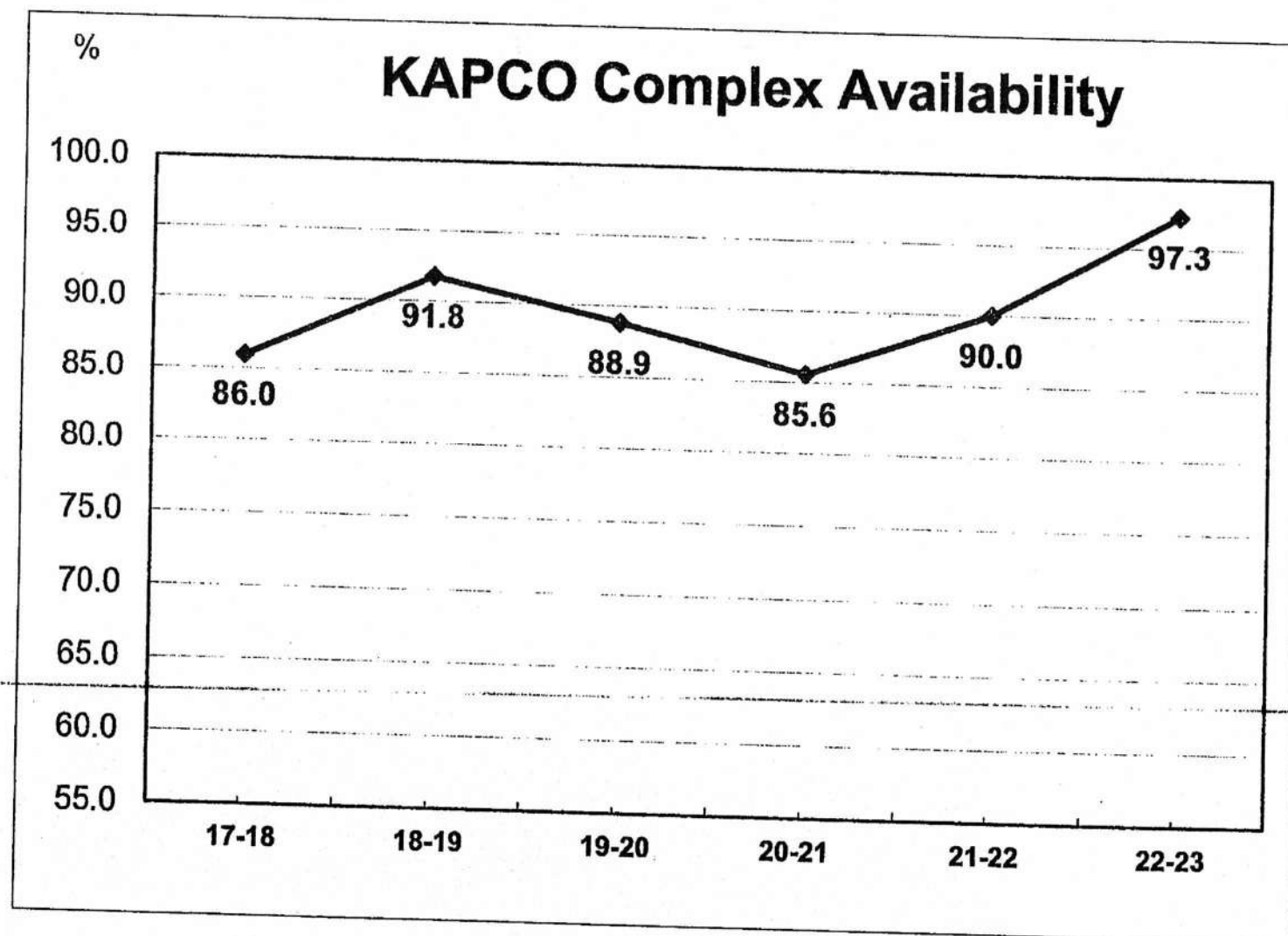
ANNEXURE N

GRAPHS





Till Oct 24, 2022



ANNEXURE O

TECHNICAL LIMITS & UNIT START-UP TIMES

SCHEDULE 2

TECHNICAL LIMITS

1. Design Limits

1.1 Start-Ups

(a) The notice required by WAPDA to the Company to initiate start-up of a Unit and synchronize to the Grid System will vary according to the length of time the Unit has been shutdown. Tables 1A and 1B below show the length of notice (in minutes) required for various conditions of start-up for gas and steam Units. The steam turbine start times must be added to the start times of the gas turbines used to provide such turbines with steam.

For purposes of this Section 1.1, c/s shall mean "Cold Start", w/s shall mean "Warm Start", and h/s shall mean "Hot Start".

TABLE 1A Start-Up Times for Gas Turbines				
UNITS	1 - 2	3 - 4	5 - 8	13 - 14
Starting Time (minutes)	4	28	10	3.3

TABLE 1B Start-Up Times for Steam Turbines			
UNITS	9 - 10	11 - 12	15
Starting Time (minutes)	c/s - 140	c/s - 20	c/s - 42
	w/s - 60	w/s - 20	w/s - 25
	h/s - 15	h/s - 10	h/s - 15

The reference to starts, starting or started means the process of firing the boiler, running up the turbine generator and synchronizing it to the Grid System.

(b) Start-up of a Steam Turbine Unit shall be classified as set forth in Table 2 below:

TABLE 2			
UNITS	9 - 10	11 - 12	15
Drum Pressure** (bar)	c/s - <12 w/s - 12-20 h/s - >20	N/A	N/A
Steam Temperature**	N/A	c/s - <100°C w/s - 100-250°C h/s - >250°C	N/A
Time after Shutdown	N/A	N/A	c/s - >60 hours w/s - 6-60 hours h/s - <6 hours

** Classification has been provided on the basis of Drum Pressure or Steam Temperature depending on the classification provided by the manufacturer.

(c) The number of yearly steam turbine Unit start-ups shall be subject to the limits set forth in Table 3 below:

TABLE 3			
UNITS	9 - 10	11 - 12	15
Recommended Starts/Year	c/s - 5 w/s - 50 h/s - [**]	c/s - 8 w/s - 80 h/s - 365	No manufacturer limits

** To be agreed by the Engineer, WAPDA and the Purchaser prior to the completion of the IDC Test and the Functional Tests.

1.2 Complex loading

(a) The Unit load ramping rates are steady rates at which the load can be raised. The maximum design load ramping rates are shown below in (MW/minute) in Table 4. The maximum design load ramping rates shown below are subject to the results of the Functional Test described in Section 2.1(f) of Schedule 4.

TABLE 4							
UNITS	1 - 2	3 - 4	5 - 8	9 - 10	11 - 12	13 - 14	15
Ramping Rate	11* 30**	5	8	c/s - 1.5 w/s - 12 h/s - 20	c/s - 2 w/s - 3 h/s - 3	11* 30**	c/s - 14 w/s - 14 h/s - 14
Load Range (%)	20-90	0-100	0-100	0-100	c/s - 35-100 w/s - 35-100 h/s - 5-100	15-100	c/s - 0-50 w/s - 0-65 h/s - 0-80

* Normal
** Fast

(b) The Unit load ranges expressed in percentages in this Schedule refer to the gross load ranges, for which the maximum ramping rates apply. Ramping rates outside of these load ranges will be slower.

(c) Temperature Stabilization

(i) During cold start only, once reaching full speed and no loading, the Unit 15 load will be required to be held steady for twenty-five (25) minutes for temperature stabilization of the turbine during load increases.

(ii) Any required stabilization for Unit 9 and 10 loads will depend on axial/surface stresses controlled by turbomax.

(iii) Subject to turbine conditions the Company may shorten or waive the requirement for one or more of the stabilization periods.

(d) Step changes in Despatched load of up to 5% of each generator are allowable provided that the generator load is greater than 0%. After such step change the new Unit or Module load must be held constant for stabilization purposes in accordance with 1.2 (c) or for a pro-rata period for lesser step changes.

(e) The Units can withstand a full load rejection and remain in a safe condition. Provided the Complex auxiliaries are operated continuously, the Units can be re-synchronized within one hour provided that the reason for the load rejection has been removed.

(f) The Complex minimum continuous loading shall be 1 gas turbine Unit at baseload plus the associated steam turbine Unit.

(g) Base load operation of Units 1 & 2 shall be defined as the load associated with a corrected turbine exhaust temperature of not more than 487°C under

any circumstances. The maximum vanadium content of residual fuel oil permissible at this exhaust temperature is 25 ppm per the manufacturer's vanadium correction curve. Vanadium content levels in the fuel of 25-50 ppm shall require lower turbine exhaust temperatures in accordance with the manufacturer's vanadium correction curve.

1.3 Frequency, Power Factor, Voltage Limits and Droop Settings

(a) The Units within the Complex will operate at 100% load with a power factor in the range 0.85 lagging to 0.97/0.95 leading which range shall not be exceeded. At no time will the generator capability curves be exceeded.

(b) The Units can operate within the range $\pm 10\%$ on the 11 kV high voltage system which range shall not be exceeded; however, the exact voltage is different for each gas turbine Unit.

(c) The Complex can operate within the frequency range 49 Hertz to 51 Hertz, and in limited and exceptional cases from 47.5 Hertz to 52.5 Hertz, which range shall not be exceeded.

(d) The Complex or individual Units will be subject to tripping, if frequency and/or voltage fluctuations outside the ranges stated in 1.3(b) and 1.3(c) occur.

(e) The Unit governor droop is adjustable in the 2-10% range.

(f) The automatic voltage regulator droop setting is adjustable in the 0-21% range.

(g) The existing 132 kV and 220 kV transmission lines are anticipated to have sufficient capacity when all 15 Units of the Complex are operating at full load. Two additional 220 kV transmission lines are being installed (scheduled completion mid 1996) in order to increase the transmission line reliability. If there is a transmission limitation before the two additional 220 kV transmission lines are completed, such transmission limitation shall be considered a Technical Limit.

(h) The generator reactive capability range in paragraph (a) above and the voltage regulation range in paragraph (b) above are each subject to change based on the results of the Functional Test described in Sections 2.1(d) and in 2.1(a), respectively.

2. Design Maintenance Limits

The cycle of Scheduled Outages is set out in Tables 5A and 5B below together with recommended durations for such inspections and outages. Time allotted for Scheduled Outages is provided for in Section 6.3 of this Agreement.

TABLE 5A
GAS TURBINE MAINTENANCE SCHEDULE AND RECOMMENDED DURATIONS

Unit No.	Equivalent Operating Hours for Inspection	Time Required for Combustion Inspection	Equivalent Operating Hours for IIGP Inspection	Time Required for HGP Inspection	Equivalent Operating Hours for overhauling	Time Required for Overhauling
1	4000 hours	7 days	N.A.	N.A.	24000 hours	50 days
2	4000 hours	7 days	N.A.	N.A.	24000 hours	50 days
3	3000 hours	7 days	6000 hours	30 days	18000 hours	50 days
4	3000 hours	7 days	6000 hours	30 days	18000 hours	50 days
5	7500 hours	7 days	22500 hours	30 days	45000 hours	50 days
6	7500 hours	7 days	22500 hours	30 days	45000 hours	50 days
7	7500 hours	7 days	22500 hours	30 days	45000 hours	50 days
8	7500 hours	7 days	22500 hours	30 days	45000 hours	50 days
13	4000 hours	7 days	25000 hours	30 days	50000 hours	50 days
14	4000 hours	7 days	25000 hours	30 days	50000 hours	50 days

TABLE 5B
STEAM TURBINE MAINTENANCE SCHEDULE AND RECOMMENDED DURATIONS

Unit No.	Running Hours for Minor Overhaul	Time Required for Minor Overhaul	Running Hours for Major Overhaul	Time required for Major Overhaul
9 - 10	25000 hours	20 days	50000 hours	60 days
11 - 12	25000 hours	20 days	50000 hours	60 days
15	25000 hours	20 days	50000 hours	60 days

Scheduled Outages thereafter continue on a three to five (3 to 5) Year cycle which must be maintained. All boiler inspections will be completed within the above timescales.

The scheduling of maintenance inspections will be compatible with regulatory requirements. All regulatory inspections will be carried out during Scheduled Outages.

TECHNICAL LIMIT

3.2 Start-Up Times for Gas Turbines

UNITS	1-2	3-4	5-8	13-14
GT start to GT Synchronisation (minutes)	4	28	10	3.3
Ramping Rate MW / Min	11	5	8	11
Load Range for Ramping Rates	0-56 MW	0-80 MW	0-82 MW	0-107 MW
GT start to GT Base Load (minutes)	13	44	20	13.0

Start-Up Times for Steam Turbines

UNITS			Module-1 (GT-1, 3 & STG-9)			Module-3 (GT-5, 6 & STG-11)			Module-5 (GT-13, 14 & STG-15)		
Star:			Module-2 (GT-2, 4 & STG-10)			Module-4 (GT-7, 8 & STG-12)					
			Cold	Warm	Hot	Cold	Warm	Hot	Cold	Warm	Hot
GT Start to STG Synchronisation(minutes) (HRSG preparation + STG rolling)			168 (GT 3&4) 144 (GT 1&2)	88 (GT 3&4) 64 (GT 1&2)	58 (GT 3&4) 34 (GT 1&2)	150	105	65	180	91	74
STG Ramping Rates MW / Min			1.2	1.9	4.8	0.36 ⁽¹⁾ & 2.35 ⁽²⁾	0.58 ⁽¹⁾ & 3.18 ⁽²⁾	3.28	4	4	4.12
STG Load Range for Ramping Rates			0-95 MW	0-95 MW	0-85 MW	0-35 ⁽¹⁾ MW & 35-82 ⁽²⁾ MW	0-35 ⁽¹⁾ MW & 35-82 ⁽²⁾ MW	0-82 MW	0-118 MW	0-118 MW	0-118 MW
STG Synchronisation to STG Base Load (minutes)			80	50	20	110	75	25	30	30	29
Overall Module timing from first GT start to STG Base Load (minutes)			248 (GT 3&4) 224 (GT 1&2)	138 (GT 3&4) 114 (GT 1&2)	78 (GT 3&4) 54 (GT 1&2)	260	180	90	210	120	103
3.4 Average Module During start-up	Ramping Rates	Full Module	1.1 (GT 3&4) 1.2 (GT 1&2)	1.9 (GT 3&4) 2.3 (GT 1&2)	3.4 (GT 3&4) 4.9 (GT 1&2)	0.9	1.3	2.7	1.5	2.6	3.1
			0.6 (GT 3&4) 0.8 (GT 1&2)	0.9 (GT 3&4) 1.6 (GT 1&2)	1.9 (GT 3&4) 3.2 (GT 1&2)						
		Half Module									

Note: The sign (GT 3&4) indicates GT-3 or GT-4 is started initially and (GT 1&2) indicates GT-1 or GT-2 is started initially in the respective modules.
STG-11 & 12 have two ramping rates in cold & warm start one from 0-35 MW & other from 35-82 MW as mentioned above.

3.5 Minimum Stable Loading

Module- 1 & 2 = 170 MW
Module- 3 & 4 = 185 MW
Module- 5 = 148 MW

3.7 Units Loading/DeLoading Ramp Rates MW/Minute

Module	Minimum Load to Base Load	Base Load to Minimum Load
1&2	2.8	2.3
3&4	5.2	3.6
5	6.2	7.4

3.9 Classification of Starts

Units	9-10			11-12			15		
Start type	Hot	Warm	Cold	Hot	Warm (1) & (2)	Cold	Hot	Warm	Cold
Time after Shutdown (Hours)	< 2	2-16	> 16	< 2	(1) 2-8 (2) 8-48	> 48	< 8	8-40	> 40

ANNEXURE P
IMS CERTIFICATES

CERTIFICATE

TÜV
AUSTRIA

**Management System as per
EN ISO 14001 : 2015**

In accordance with TDV AUSTRIA procedures, it is hereby certified that

KAPCO

KOT ADDU POWER COMPANY LIMITED (KAPCO)
Kot Addu Power Complex, Kot Addu, District Bhaddigarh
PUNJAB PAKISTAN

Applies an Environmental Management System in line with the above Standard for the following Scope

OPERATION AND MAINTENANCE OF 1000 MW CCPP.

Certificate Registration No.: 202018000032

Valid until: 2023-08-12

**CONFIRMATION BOOKY
AT TOW AUSTRALIA**

Lahtonen, 2019-05-13

This certification was conducted in accordance with TÜV AUSTRIA auditing and certification procedures and is subject to regular surveillance audits.

THE AUSTRALIAN HELLBOSS
4025, WILSON ST, MELB.
694-1991 4025 AUSTRALIAN HELLBOSS
WILSON ST, MELB.





CERTIFICATE

TUV
AUSTRIA

**Management System as per
OHSAS 18001 : 2007**

In accordance with TUV AUSTRIA procedures, it is hereby certified that:

KAPCO

**KOT ADDU POWER COMPANY LIMITED (KAPCO)
Kot Addu Power Complex, Kot Addu, District Muzaffargarh
PUNJAB PAKISTAN**

Applies an Occupational Health & Safety Management System in line with the above Standard for the following Scope:

OPERATION AND MAINTENANCE OF 1320 MW CCPP.

EN Scope / Risk category: 15, 25 // A

Certificate Registration No.: 2019190071033

Valid until: 2021-05-11*

Certification Body
at TUV AUSTRIA

Lahore, 2019-05-13

This certification was conducted in accordance with TUV AUSTRIA auditing and certification procedures and is subject to regular surveillance audits.

*The validity of the present certificate is dependent on the results of the surveillance audits, according to the regulations of TUV AUSTRIA.

**TUV AUSTRIA HELLAS
421, Mesogion Ave.
GR-15122 Athens, Greece
www.tuv.austria/hellas**





CERTIFICATE

TUV
AUSTRIA

**Management System as per
EN ISO 9001 : 2015**

In accordance with TUV AUSTRIA procedures, it is hereby certified that

KAPCO


**KOT ADDU POWER COMPANY LIMITED (KAPCO)
Kot Addu Power Complex, Kot Addu, District Mirzafargarh
PUNJAB PAKISTAN**

Applies a Quality Management System in line with the above Standard for the following Scope

OPERATION AND MAINTENANCE OF 1000 MW CCPP.

Certificate Registration No.: 20007150000001

Valid until: 2022-05-12


Head of Office
TUV
Certification Body
at TUV AUSTRIA

Laboratory: 20109-05-13

This certification was conducted in accordance with TUV AUSTRIA auditing and certification procedures and is subject to regular surveillance audits.

TUV AUSTRIA HELLAS
4021, Neapoliou Ave.
GR-153 43 Athens, Greece
www.tuv.austria/hellas



04/07/2015

04/07/2015-4

04/07/2015-4

ANNEXURE Q

REPORT SUBMITTED TO EPA PUNJAB



EPA Certified

PAK GREEN ENVIRO-ENGINEERING (Pvt.) Ltd.

ISO/IEC 17025:2017 Accredited Testing Lab, ISO 9001:2015, ISO 14001:2015, ISO 45001:2018

Doc #: PGG/LAB/SE/FF/063 Rev. Date: 27-Jan-22 Rev. # 01

Head Office: 46-M, Gulberg III, Lahore-Pakistan. Ph: +9242-35441444 Cell: 0303-4442334

TEST REPORT

Ref #: PGG/LAB/2022-3649/SE

Date: 10-Aug-22

Name of Industry/Client:
Site Location:
Nature of Monitoring:
Monitoring By:
Emission Source:
Capacity:
Fuel:
Monitoring Instrument:
Monitoring Date:

Kot Addu Power Company Limited
Kot Addu Power Complex, Kot Addu, District Muzaffargarh
Stack Emissions
Pak Green Laboratories
Heat Recovery Steam Generator # 1
104 MW
Natural Gas
MRU, Ringelmann Scale
30-Jul-22

Results:

Sr. No.	Parameters	Methods	Units	PEQS	Reading 1	Reading 2	Reading 3	Average
1.	O ₂	Electrochemical	%	NGVS	13.61	13.60	13.59	13.60
2.	CO ₂	NDIR/ Method 10	%	NGVS	4.59	4.55	4.54	4.56
3.	CO	OTM-39	mg/Nm ³	800	0.00	0.00	0.00	0.00
4.	NO	OTM-39	mg/Nm ³	NGVS	257.40	256.08	254.76	256.08
5.	NO ₂	OTM-39	mg/Nm ³	NGVS	71.05	69.02	66.99	69.02
6.	NO _x	OTM-39	mg/Nm ³	400	328.45	325.10	321.75	325.10
7.	SO _x	USEPA Method 8	mg/Nm ³	1700	11.28	8.46	5.64	8.46
8.	Smoke	Ringelmann Scale	%	40	0	0	0	0
9.	Temperature	-	°C	-	201.6	201.5	201.4	201.5

End of Report

PEQS: Punjab Environmental Quality Standards

NGVS: No Guideline Value Set

Remarks: All parameters are in compliance with PEQS Limits

Terms & Conditions:

- Analysis was conducted on the request of project proponent for his own use/PEQS Compliance.
- Report cannot be used regarding compliance of any complaint, EPO or any other court case.
- This report should be reproduced as a whole and not in parts.
- The responsibility of the ethical use of the results reported in this report lies with the client. Consequently, the laboratory is absolved of its responsibility for any claim that may result through the use by the client or others of the results appearing in this report.
- The report is not valid for any negotiations.
- Dually Calibrated instrument was used during monitoring.

Field Analyst	Chief Analyst	Laboratory Incharge





EPA Certified

PAK GREEN ENVIRONMENTAL ENGINEERING (Pvt.) Ltd.

ISO/IEC 17025:2017 Accredited Testing Lab, ISO 9001:2015, ISO 14001:2015, ISO 45001:2018

Lab # PGG/EN-17025 Rev. Date: 27-Jan-22 Rev. # 01

Head Office: 46-M, Gulberg III, Lahore-Pakistan. Ph: +9242-3544144 Cell: 0303-4442334

TEST REPORT

Ref #: PGG/LAB/2022-4338/SF

Date: 29-Sep-22

Name of Industry/Client: Kot Addu Power Company Limited
Site Location: Kot Addu Power Complex, Kot Addu, District Muzaffargarh
Nature of Monitoring: Stack Emissions
Monitoring By: Pak Green Laboratories
Emission Source: Heat Recovery Steam Generator # 14
Capacity: 104 MW
Fuel: Natural Gas
Monitoring Instrument: TESTO 350 Old, Ringelmann Scale
Monitoring Date: 19-Sep-22
Validated By EPA Representative: Mr Shamshad, RO, EPA (Lab), Multan

Results:

Sr. No.	Parameters	Methods	Units	PEQS	Reading 1	Reading 2	Reading 3	Average
1.	O ₂	Electrochemical	%	NGVS	15.61	15.60	15.59	15.60
2.	CO ₂	NDIR/ Method 10	%	NGVS	4.59	4.58	4.48	4.55
3.	CO	OTM-39	mg/Nm ³	800	0.00	0.00	0.00	0.00
4.	NO	OTM-39	mg/Nm ³	NGVS	258.72	257.40	256.08	257.40
5.	NO ₂	OTM-39	mg/Nm ³	NGVS	40.60	38.57	36.54	38.57
6.	NO _x	OTM-39	mg/Nm ³	400	299.32	295.97	292.62	295.97
7.	SO _x	USEPA Method 8	mg/Nm ³	1700	183.30	183.30	180.48	182.36
8.	Smoke	Ringelmann Scale	%	40	20	20	20	20
9.	Temperature	-	°C	-	181.6	181.5	181.4	181.5
10.	Particulate Matter	USEPA Method 17	mg/Nm ³	300	33.5			

End of Report

PEQS: Punjab Environmental Quality Standards

NGVS: No Guideline Value Set

Remarks: All parameters are in compliance with PEQS Limits

Terms & Conditions:

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- The report is not valid for any negotiations.
- Dually Calibrated instrument was used during monitoring.

Field Analyst	Chief Analyst	Laboratory Incharge



LAB 180
17025





PAK GREEN ENVIRONMENTAL ENGINEERING (Pvt.) Ltd.

ISO/IEC 17025:2017 Accredited Testing Lab, ISO 9001:2015, ISO 14001:2015, ISO 45001:2018

Head Office: 46-M, Gulberg III, Lahore-Pakistan. Ph: +9242-35441444 Cell: 0303-4442334

EPA Certified

TEST REPORT

Ref #: PGG/LAB/2022-4334/WW

Date: 29-Sep-22

Name of Industry/Client:
Site Location:

Kot Addu Power Company Limited
Kot Addu Power Complex, Kot Addu, District
Muzaffargarh

Nature of sample:
Sampling By:
Sample source:
Sampling type (Grab/Composite):
Sample Code:
Date of sampling:
Validated By EPA Representative:

Waste water
Pak Green Laboratories
Dispose of CCR # 3 Pit
Grab
WW-1176
19-Sep22
Mr Shamshad, RO, EPA (Lab), Multan

Results:

Sr. No.	Parameters	Unit	Method / Technique	PEQS	Results
1.	pH	---	APHA-4500-H ⁺ B	6-9	8.040 at 26.9°C
2.	Temperature increase	°C	APHA-2550 B	≤ 3	0.28
3.	Biological Oxygen Demand (BOD ₅ at 20 °C)	mg/L	APHA-5210 D	80	BDL
4.	Chemical Oxygen Demand (COD) ^	mg/L	APHA-5220 B	150	10
5.	Total Suspended Solids (TSS)	mg/L	APHA-2540 D	200	08
6.	Total Dissolved Solids (TDS) ^	mg/L	APHA-2540 C	3500	880
7.	Greases & Oil	mg/L	APHA-5520 B	10	BDL
8.	Phenolic Compound (As Phenol)	mg/L	APHA-5530 D	0.1	0.001
9.	Chloride (as Cl ⁻) ^	mg/L	APHA-4500-Cl B	1000	60
10.	Fluoride (F ⁻)	mg/L	APHA-4500-F-D	10	0.9
11.	An Ionic detergent as MBAs	mg/L	APHA 5540 C	20	0.026
12.	Sulphate (SO ₄ ²⁻) ^	mg/L	APHA-4500-SO ₄ C	600	99
13.	Sulphide (S ²⁻)	mg/L	APHA-4500-S ²⁻ P	1.0	BDL
14.	Ammonia (NH ₃) ^	mg/L	APHA-4500NH ₃ C	40	0.5
15.	Cadmium (Cd)	mg/L	APHA-3111 B	0.1	BDL
16.	Chromium (Trivalent & Hexavalent)	mg/L	APHA-3111 B	1.0	BDL
17.	Copper (Cu)	mg/L	APHA-3111 B	1.0	0.0096
18.	Lead (Pb)	mg/L	APHA-3111 B	0.5	BDL
19.	Mercury (Hg)	mg/L	APHA-3112 B	0.01	BDL
20.	Selenium (Se)	mg/L	APHA-3114 C	0.5	BDL

Page:





PAK GREEN ENVIRO-ENGINEERING (PVT.) LTD.

ISO/IEC 17025:2017 Accredited Testing Lab, ISO 9001:2015, ISO 14001:2015, ISO 45001:2018

Head Office: 46-M, Gulberg III, Lahore-Pakistan. Ph: +9242-35441444 Cell: 0303-4442334

EPA Certified

Ref #: PGG/LAB/2022-4334/WW

Date: 29-Sep-22

Results:

Sr. No.	Parameters	Unit	Method / Technique	PEQS	Results
21.	Nickel (Ni)	mg/L	APHA-3111 B	1.0	BDL
22.	Silver (Ag)	mg/L	APHA-3111 B	1.0	BDL
23.	Total Toxic Metals (Cd, Cr, Cu, Pb, Hg, Se, Ni, Ag, As, Ba, B)	mg/L	-	2.0	0.0181
24.	Zinc (Zn)	mg/L	APHA-3111 B	5.0	BDL
25.	Arsenic (As)	mg/L	APHA-3114 C	1.0	BDL
26.	Barium (Ba)	mg/L	APHA-3111 D	1.5	BDL
27.	Iron (Fe)	mg/L	APHA-3111 B	8.0	0.0033
28.	Manganese (Mn)	mg/L	APHA-3111 B	1.5	0.0085
29.	Boron (B)	mg/L	APHA-3111 D	6.0	BDL
30.	Chlorine (Cl ₂)	mg/L	APHA-4500 Cl B	1.0	0.01
31.	Sodium	mg/L	APHA-3111 B	-	114.9350
32.	Cyanide (as CN ⁻)	mg/L	APHA-4500-CN F	1.0	BDL

.....End of Report.....

PEQS: Punjab Environmental Quality Standard

^PNAC Accredited

BDL: Below Detection Limit

Remarks: All Parameters are in compliance with PEQS limit.

Terms & Conditions:

- Analysis was conducted on the request of project proponent for his own use/PEQS Compliance.
- Report cannot be used regarding compliance of any complaint, EPO or any other court case.
- This report should be reproduced as a whole and not in parts.
- The responsibility of the ethical use of the results reported in this report lies with the client. Consequently, the laboratory is absolved of its responsibility for any claim that may result through the use by the client or others of the results appearing in this report.
- The left-over sample (if so available) shall be retained for fifteen days after the issuance of the report unless otherwise negotiated between the client and the laboratory.
- The report is not valid for any negotiations.
- Dually Calibrated instruments were used during analysis.

Lab Analyst	Chief Analyst	Laboratory Incharge



EPA Certified

PAK GREEN ENVIRONMENTAL ENGINEERING (Pvt.) Ltd.

ISO/IEC 17025:2017 Accredited Testing Lab, ISO 9001:2015, ISO 14001:2015, ISO 45001:2018

Head Office: 46-M, Gulberg III, Lahore-Pakistan. Ph: +9242-35441444 Cell: 0303-4442334

TEST REPORT

Ref #: PGG/LAB/2022-4333/WW

Date: 29-Sep-22

Name of Industry/Client:
Site Location:

Kot Addu Power Company Limited
Kot Addu Power Complex, Kot Addu, District
Muzaffargarh

Nature of sample:
Sampling By:
Sample source:
Sampling type (Grab/Composite):
Sample Code:
Date of sampling:
Validated By EPA Representative:

Waste water
Pak Green Laboratories
Dispose of Block # 3 (GMZ)
Grab
WW-1175
19-Sep22
Mr Shamshad, RO, EPA (Lab), Multan

Results:

Sr. No.	Parameters	Unit	Method/Technique	PEQS	Results
1.	pH	—	APHA-4500-H ⁺ B	6-9	7.860 at 26.8°C
2.	Temperature increase	°C	APHA-2550 B	≤ 3	0.1
3.	Biological Oxygen Demand (BOD ₅ at 20°C)	mg/L	APHA-5210 D	80	BDL
4.	Chemical Oxygen Demand (COD) ^	mg/L	APHA-5220 B	150	08
5.	Total Suspended Solids (TSS)	mg/L	APHA-2540 D	200	05
6.	Total Dissolved Solids (TDS) ^	mg/L	APHA-2540 C	3500	1720
7.	Greases & Oil	mg/L	APHA-5520 B	10	BDL
8.	Phenolic Compound (As Phenol)	mg/L	APHA-5530 D	0.1	BDL
9.	Chloride (as Cl ⁻) ^	mg/L	APHA-4500-Cl B	1000	465
10.	Fluoride (F ⁻)	mg/L	APHA-4500-F-D	10	1.1
11.	An Ionic detergent as MBAs	mg/L	APHA 5540 C	20	0.044
12.	Sulphate (SO ₄ ²⁻) ^	mg/L	APHA-4500-SO ₄ C	600	160
13.	Sulphide (S ²⁻)	mg/L	APHA-4500-S ²⁻ F	1.0	BDL
14.	Ammonia (NH ₃) ^	mg/L	APHA-4500NH ₃ C	40	0.9
15.	Cadmium (Cd)	mg/L	APHA-3111 B	0.1	BDL
16.	Chromium (Trivalent & Hexavalent)	mg/L	APHA-3111 B	1.0	0.0099
17.	Copper (Cu)	mg/L	APHA-3111 B	1.0	0.0197
18.	Lead (Pb)	mg/L	APHA-3111 B	0.5	BDL
19.	Mercury (Hg)	µg/L	APHA-3112 B	0.01	BDL
20.	Selenium (Se)	mg/L	APHA-3114 C	0.5	BDL

Page





PAK GREEN

ENVIRONMENTAL ENGINEERING (PVT.) LTD.

ISO/IEC 17025:2017 Accredited Testing Lab, ISO 9001:2015, ISO 14001:2015, ISO 45001:2018

Head Office: 46-M, Gulberg III, Lahore-Pakistan. Ph: +9242-35441444 Cell: 0303-4442334

EPA Certified

Ref #: PGG/LAB/2022-4333/WW

Date: 29-Sep-22

Results:

Sr. No.	Parameters	Unit	Method / Technique	PEQS	Results
21.	Nickel (Ni)	mg/L	APHA-3111 B	1.0	BDL
22.	Silver (Ag)	mg/L	APHA-3111 B	1.0	BDL
23.	Total Toxic Metals (Cd, Cr, Cu, Pb, Hg, Se, Ni, Ag, As, Ba, B)	mg/L	-	2.0	0.1204
24.	Zinc (Zn)	mg/L	APHA-3111 B	5.0	0.3003
25.	Arsenic (As)	mg/L	APHA-3114 C	1.0	0.0017
26.	Barium (Ba)	mg/L	APHA-3111 D	1.5	BDL
27.	Iron (Fe)	mg/L	APHA-3111 B	8.0	2.8010
28.	Manganese (Mn)	mg/L	APHA-3111 B	1.5	0.0891
29.	Boron (B)	mg/L	APHA-3111 D	6.0	BDL
30.	Chlorine (Cl ₂)	mg/L	APHA-4500 Cl B	1.0	0.02
31.	Sodium	mg/L	APHA-3111 B	-	124.6637
32.	Cyanide (as CN ⁻)	mg/L	APHA-4500-CN F	1.0	BDL

End of Report.....

PEQS: Punjab Environmental Quality Standard

^PNAC Accredited

BDL: Below Detection Limit

Remarks: All Parameters are in compliance with PEQS limit.

Terms & Conditions:

- Analysis was conducted on the request of project proponent for his own use/PEQS Compliance.
- Report cannot be used regarding compliance of any complaint, EPO or any other court case.
- This report should be reproduced as a whole and not in parts.
- The responsibility of the ethical use of the results reported in this report lies with the client. Consequently, the laboratory is absolved of its responsibility for any claim that may result through the use by the client or others of the results appearing in this report.
- The left-over sample (if so available) shall be retained for fifteen days after the issuance of the report unless otherwise negotiated between the client and the laboratory.
- The report is not valid for any negotiations.
- Dually Calibrated instruments were used during analysis.

Lab Analyst	Chief Analyst	Laboratory Incharge



ANNEXURE R

CERTIFICATE OF APPRECIATION

Certificate
OF APPRECIATION

20th Annual Environment
Excellence Awards 2023

After careful consideration of track record,
services and performance of

KOT ADDU POWER COMPANY LIMITED

This certificate is being awarded on 9th August 2023 - Karachi.

ORGANIZED BY



NFEH
National Forum for
Environment & Health
www.nfeh.org.pk



M. Nacem Qureshi
President, NFEH

KAPCO/CEO/2024/505

July 29, 2024

The Registrar
National Electrical Power Regulatory Authority
NEPRA Tower, Ataturk Avenue (East)
G-5/1, Islamabad, Pakistan

SUBJECT: **CORRIGENDUM – REVISION OF GROSS CAPACITY FROM 1600 MW TO 550 MW AS PER IGCEP -APPLICATION FOR GENERATION LICENSE EXTENSION PROPOSED FOR GENERATION LICENSE NO. IPGL/020/2004 RELATING TO 1600MW (GROSS) KAPCO COMPLEX LOCATED AT KOT ADDU DISTRICT MUZAFFARGRAH, PUNJAB**

Dear Sir,

This is with reference to KAPCO Application for Extension of Generation License bearing reference No. KAPCO/CEO/2024/504 dated June,14,2024 (KAPCO Application). We would like to submit a corrigendum (01 page) to notify an amendment in KAPCO Application related to Section 4: The Proposed Text for Extension / Modification of Generation License, which is to amended Section 4 to revise the Gross Capacity from 1600 MW to 550 MW, which corresponds to 500 MW net capacity as per requirement of IGCEP 2022-31 as duly approved by NEPRA Authority.

We request that KAPCO Application be read subject to the corrigendum attached herewith and marked Annex A.

Thanking you,

Yours faithfully,
For and on behalf of KOT ADDU POWER COMPANY LIMITED



Aftab Mahmood Butt
Chief Executive

Enclosure: Annex A (Corrigendum of Section 4 (1 page))

4. PROPOSED TEXT FOR GENERATION LICENSE EXTENSION/MODIFICATION

4.1. THE PROPOSED TEXT

- 4.1.1. In view of the matters set out in this Generation License Modification/ Extension Application, including, without limitation, to ensure that the term of the Generation License caters to ensure its term is valid until the Proposed Generation License Expiry Date, the Proposed Generation License Extension amends Article 4 of the Generation License as follows: “(1) Pursuant to Rule 5 of the Rules, this License is granted/ modified for a further term of seven (7) years as per below schedule:

Table:1 A

Revised Energy Block	Units	Gross Capacity	Net Capacity		Remarks
			RLNG/GAS	FO/HSD	
EB-I	GT: 13-14 & STG:15	400 MW	347 MW	334 MW	500 MW retained till June 2027 in the submitted IGCEP 2024-34, Page 39 annexure- J
EB-IIA	GT: 1 & STG: 9* with HRSG-1	150 MW	148 MW	144 MW	
Complex		550 MW	495 MW	478	

The Generation license of following units will end on September 21,2024 and the Company may apply for Generation License of the following units at a later date, which may be in line with the launch of CTBCM and hence the Authority is requested to modify the license accordingly.

Table-1B

EB-IIA	GT: 2, STG: 10* with HRSG-2	150 MW	150 MW	145MW	Generation License will expire dated September 21,2024 and Company may apply later on as per CTBCM
EB-IIC	GT: 5-6 STG: 11	300 MW	236 MW	228 MW	
EB-IIB	GT: 7-8 STG: 12	300 MW	247 MW	236 MW	
EB-III	GT: 3-4, STG: 9/10*	300 MW	258 MW	249 MW	
Total Capacity to be retired		1050 MW	891 MW	858 MW	