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September 24, 2021

Sofia Municipality
33 Moskovska Street
Sofia 1000 Bulgaria

TSEAD Task 2 Plan Report
Sofia Municipality
B&V Project 408043

Attention: Deputy Mayor Barbalov

Subject: Feasibility Study Task 2 Report

The attached report describes all work performed and findings from Task 2 of the Technical Advisory Contract between Sofia Municipality (Client) and Black & Veatch Management Consulting, LLC (Black & Veatch), dated June 18, 2021 (Contract). Task 2 covers the development of upgrade, remediation, and recapitalization plan (Plan) for TSEAD. The attached report includes an assessment of the technical recommendations made in the full report developed by the Sofia Municipal Council working group, dated September 2019, translated in English (2019 Report). The report also outlines the initial Plan parameters and recommendations and identifies specific projects to achieve the Plan objectives.

Task 2 of the Study was performed by Black & Veatch with support from Green Energy Advisors LLC (Green Energy) and Marathon Capital LLC (Marathon).

As you know, the current operational and financial condition of TSEAD is of critical importance. The number and enormity of the company's challenges requires a large scale and comprehensive remediation program. We believe the proposed Plan included in the attached report fully meets that requirement and is fully achievable. Once approved we would expect that necessary planning will take approximately 6 to 9 months, and construction an additional 30 months. Thereafter, TSEAD will be fully capable of providing reliable, affordable heat in a financially sustainable and environmentally compliant way for at least 25 years.

We take this opportunity to thank the Municipality and the management and staff of TSEAD for their outstanding cooperation and support in the preparation of the Plan.

Very truly yours,

Black & Veatch Management Consulting, LLC

DRAFT

UPGRADE, REMEDIATION, AND CAPITALIZATION FEASIBILITY STUDY TASK 2 REPORT

B&V PROJECT NO. 408043

PREPARED FOR

Sofia Municipality

24 SEPTEMBER 2021

BLACK & VEATCH

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1.0 INTRODUCTION

This document and associated attachments encompass the report describing all work performed and findings from Task 2 of the Technical Advisory Contract between Sofia Municipality (Client) and Black & Veatch Management Consulting, LLC (Black & Veatch), dated June 18, 2021 (Contract). The Contract is being completed with the support of the U.S Trade and Development Agency (USTDA), through a USTDA grant to the Sofia Municipality. Task 2 covers a feasibility study (Study) to develop an upgrade, remediation, and recapitalization plan (Plan) for the Sofia district heating company, Toplofikatcia Sofia EAD (TSEAD). This report includes an assessment of the technical recommendations made in the full report developed by the Sofia Municipal Council working group, dated September 2019, translated in English (2019 Report). This report also outlines the initial Plan parameters and recommendations and identifies specific projects to achieve the Plan objectives.

1.1 Study Overview

The objective of this Study is to create a comprehensive Plan to assist the Sofia Municipality in coordination with TSEAD in addressing issues with plant and equipment, operations, and finances (Project). The Plan examines possible upgrades to or replacements of several of TSEAD's existing aging cogeneration and boiler plants and distribution network, which are utilized to deliver heat and electricity to more than 1 million people. The Plan includes first a review of specific recommendations set out in the 2019 Report for improvements to plant and equipment, as well as emissions remediation. The Plan then includes proposals for specific, phased implementation projects, as well as project financing and corporate refinancing proposals.

The Task 2 scope and associated report section is summarized below. The Terms of Reference (TOR) of the Contract (TDA-TOR Final Clean Eng 29.01.2021) includes additional detail regarding the Plan.

- Task 2: Develop Upgrade, Remediation, and Recapitalization Plan
  - Technical
    - Identify major gaps in the 2019 Report which need further due diligence; (Section 3.3)
    - Assess the technical recommendations made in the 2019 Report; (Section 3.1 and 3.2)
    - Establish the baseline to be used for performance measuring; (Section 3.4)
    - Assess expected operational and financial impact of the waste to energy combined heat and power (WECHP) plant; (Section 4.1)
    - Assess the design and current condition of distribution infrastructure and identify potential improvements; (Section 4.2)
    - Review potential cogeneration options to reliably meet the hot water demand and provide additional power to the grid. Consideration will be provided to any limits related to grid connection, fuel supply, water supply, wastewater discharge, emissions, available area, and hot water demand. The cogeneration option will include consideration of WECHP plant for Sofia location. (Section 4.3 and Section 6.2)
  - Financial
    - Assess TSEAD's current financial condition and objectives for restructuring; (Section 4.1)

        - Survey available sources of funding for TSEAD; (Section 4-4)
        - Explore investment structure options within continued Sofia Municipality's ownership of TSEAD. (Section 4-5)
    - Regulatory
        - Assess alternative management structures, including contract management; (Section 5-1)
        - Assess the current and potential future role of TSEAD in the national electrical power systems. Consider the capacity considerations discussed with the national electric grid operator (Section 5-2)

1.2 Study Methodology

Black & Veatch was provided the 2019 Report prepared by TSEAD for the basis of our review. However, during the Study, the 2019 Report was supplemented by additional revised studies and additional data provided by TSEAD. summary of the methodology utilized to complete Task 2 of the Contract is summarized below.

- 2019 Report – TSEAD provided Black & Veatch with the 2019 Report for review.
- Initial Data Request – Black & Veatch, Green Energy, and Marathon submitted to TSEAD an initial set up data requests, to gather supplemental information necessary to complete the scope of work. Data requested included information such as historical operational, performance, outage, financial, and emissions information; design and condition assessment information for major equipment and the distribution network; and natural gas, electric, water, and wastewater interconnection information. Initial data was provided via an electronic collaboration site, as well as gathered during the Kickoff Meeting and Site Visits.
- Kickoff Meeting – Black & Veatch, Green Energy, and Marathon attended a Kickoff Meeting with Sofia Municipality and TSEAD to establish communication protocols, review roles and responsibilities, obtain clarifications of Sofia Municipality's goals and objectives, and discuss the Work Plan.
- Site Visits – Black & Veatch visited TSEAD's facilities being evaluated under the Study, as well as key points on Sofia Municipality's distribution system to review site conditions and existing infrastructure.
- Initial Plan Development – Based on the initial data gathered and findings from the Kickoff Meeting and Site Visits, Black & Veatch, Green Energy, and Marathon developed a high-level initial Plan which was presented to and further defined and refined through coordination with Sofia Municipality and TSEAD.
- Supplemental Data Requests – Black & Veatch, Green Energy, and Marathon submitted to TSEAD additional questions and data requests throughout completion of Task 2, as necessary, to gather supplemental information necessary to complete the scope of work. TSEAD provided responses and additional data and studies in response to the supplemental data requests.
- Task 2 Deliverable: Black & Veatch, Green Energy, and Marathon prepared this report outlining the Plan parameters and recommendations and identifying specific projects to achieve the Plan objectives.

1.3 TSEAD Overview

TSEAD currently provides hot water to majority of the approximately 1.3 million residents of the City of Sofia, Bulgaria. The original Sofia thermal power plant was commissioned in 1949, while TSEAD was established as a registered enterprise in 1957. Currently, the sole owner of the equity is Sofia Municipality. The company is managed by the Supervisory Board.

TSEAD has licenses issued from the Energy and Water Regulation Commission (EWRC) for heat and electricity generation and for heat energy transmission on the territory of Sofia. The company has four main district heating regions (DHR), these include DHR Sofia Central, DHR Sofia East, DHR Zemlyane, DHR Lyulin. There are seven additional smaller district heating plants. Only two of the 11 district heating plants are combined heat and power (CHP) plants, the remaining nine plants produce hot water for district heating.

The assets included in this review have a combined gross installed electrical generation capacity of 238 megawatts (MW), combined gross capacity of 4186 megawatts thermal (MWt). Table 1-1 presents an overview of the TSEAD plants.

Table 1-1 TSEAD District Heating Plants

Plant Name	Installed Electric Power (MW)	Actual Electric Capacity (MW)	Installed Heating Capacity (MWt)	Actual Heating Capacity (MWt)	Commercial Operation Year
SOFIA CENTRAL	72	70	1323	1107	1949
SOFIA East"	166.8	166.8	1464	1253	1964
ZEMELYANE			581	536	1972
LYULIN			581	512	1977
Suha Reka			35	32	1976
H. DIMITAR			46.8	40	1983
LEVSKI G			43.6	40	1991
ORLANDOVTSI			5	4	1985
OVCHA KUPEL 1			43.6	40	1990
VVAC OVCHA KUPEL 2			43.6	40	1988
INJSTROY			19.7	19	1980
Total	**238.8**	**236.8**	**4186.3**	**3623**	

The details for the major equipment at these DHRs are shown in Tables 1-2 through 1-5.

Table 1-2 Major Equipment at Sofia Central

Unit	Rated Capacity	Year of Commission	Last Major Overhaul	Comments
Steam Generator 6	220 t/h	1957	1999	Minimum load 100 t/h, Steam produced at 510 C, 9.8 MPa
Steam Generator 7	220 t/h	1963	1997	Minimum load 100 t/h, Steam produced at 540 C, 9.8 MPa
Steam Generator 8	220 t/h	1964	2009	Minimum load 100 t/h, Steam produced at 540 C, 9.8 MPa
Steam Generator 9	220 t/h	1985	NA	Minimum load 100 t/h, Steam produced at 540 C, 9.8 MPa
Steam Turbine TG-8	25 MW	1985	2016	Back pressure turbine with exhaust range 0.8-1.6 MPa. Steam inlet at 9 MPA. Nominal Steam Consumption 190 t/h
Steam Turbine TG-8A	12 MW	2015	NA	Back pressure turbine. Steam Inlet at 1.0 MPa, Exhaust pressure 0.1-0.25 MPa
Steam Turbine TG-9	35 MW	2014	NA	Condensing turbine with exhaust range 0.358-0.811 MPa. Steam inlet at 8.8 MPA. Nominal Steam Consumption 0-25 t/h
Hot water boilers BK1, BK2, BK3, BK4 BK5, and BK6	116.3 MW each	1967 -1995	2002 -2010	-

Table 1-3 Major Equipment at Sofia East

Unit	Rated Capacity	Year of Commission	Last Major Overhaul	Comments
Steam Generator 1	220 t/h	1964	1994	Steam at 540 C, 9.6 MPa, 93% Boiler Efficiency (LHV)
Steam Generator 2	220 t/h	1964	1990	Steam at 540 C, 9.6 MPa, 93% Boiler Efficiency (LHV)
Steam Generator 3	220 t/h	1967	2005	Steam at 540 C, 9.6 MPa, 93% Boiler Efficiency (LHV)
Steam Generator 4	220 t/h	1968	2002	Steam at 540 C, 9.6 MPa, 93% Boiler Efficiency (LHV)
Steam Generator 5	220 t/h	1988	-	Steam at 535 C, 13.53 MPa, 93% Boiler Efficiency (LHV)
Steam Generator 6	220 t/h	1988	-	Steam at 535 C, 13.53 MPa, 93% Boiler Efficiency (LHV)
Steam Generator 7	220 t/h	1989	-	Steam at 535 C, 13.53 MPa, 93% Boiler Efficiency (LHV)
Water Boilers 1-8	116.3 MWt each	1974-1982	1984-1999 ; Boiler 6 in 2009	-
Steam Turbine, TG-1, TG-2	30 MW each	TG-1 and TG-2 in 1964,	TG-1 in 2010 TG-2 in 2011	Steam Inlet at 535 C, 8.8 MPa; exhaust at 1 MPa
Steam Turbine TG-3, TG-4	40.9 MW	TG-4 in 2019 TG-3 in 2021	Siemens SST-300 Steam turbine	Steam Inlet at 535 C, 8.91MPa; exhaust at 1 MPa
Steam Turbine TG-5	66 MW	1988	2016	Steam Inlet at 530 C, 12.75 MPa; exhaust at 1 MPa

Table 1-4 Major Equipment at Zemlyane

Unit	Rated Capacity	Year of Commission	Last Major Overhaul	Comments
Boiler BK1	116.3	1999	-	-
Boiler BK2	116.3	2000	-	-
Boiler BK3	116.3	1976	2010-Replacement of convective packages and screens	-
Boiler BK4	116.3	1976	2019-Replacement of convective packages and screens	-
Boiler BK5	116.3	1982	2013-Replacement of convective packages and screens	-
Industrial Boiler No 1, 2 and 3	12 t/h each	No 1 and No. 2 in 1972, No. 3 in 1981	Unit 1 in 2008, Unit 2 in 2001, Unit 3 in 2002	Produces steam for internal use

Table 1-5 Major Equipment at Lyulin

Unit	Rated Capacity	Year of Commission	Last Major Overhaul	Comments
Boiler BK1	116.3	1977	1992 (Replacement of Convective Section)	-
Boiler BK2	116.3	1977	2013 (Replacement of Convective Section), 2019 (Replacement of front and side screens)	-
Boiler BK3	116.3	1998	2014 (Replacement of front screens and side screens)	-
Boiler BK4	116.3	1979	2014 (Replacement of front screens and side screens)	-
Boiler BK5	116.3	1989	2003 (Replacement of front screens and side screens)	-
Industrial Boilers 1, 2 and 3	12 t/h each	No 1 and No. 2 in 1977, No. 3 in 1996	Unit 1 and Unit 2 in 2010, Unit 3 in 2015	Produces steam for internal use

2.0 TSEAD Plan Objectives

Based on the site visit and review of the data acquired during the diligence process, Black & Veatch identified the following principal objectives that should be addressed in the Plan.

2.1.1 Reduce NOx Emissions to Meet European Union Compliance

According to the Industrial Emissions Directive 2010/75/EU, the existing boilers are to meet a NO_X emission limit of 100 mg/Nm^3. These limits represent the minimum requirements. The emissions data from February 8 through February 17, 2021, along with the fines imposed on TSEAD as a result of these high emissions are shown in Table 2-1. The results are presented on the stack basis with multiple boilers connected to a single stack. Water Boiler 5 at Sofia Central is not included, as it has not been operational since 2009. TSEAD is currently far exceeding the 100 mg/Nm^3 NOx emissions limits allowed by European Union (EU) emission directive. As a result, they not only have incurred significant fines for exceeding the limits but also have negatively impacted the public image of TSEAD.

Table 2-1 TSEAD February 8 through 17, 2021 Emissions

Plant	Equipment	Load [%]	NO_x [mg/Nm^3]	Fine [BGN]
Sofia Central	Steam Generators 8, 9 and Water Boilers 1, 2, 3, 4, 6	85	431	10,632
	Steam Generator 6, 7	85	384	18,050
Sofia East	Steam Generator 2	74	176	1,466
	Steam Generator 4	78	220	4,518
	Steam Generator 5	90	240	3,991
	Steam Generator 7	80	274	7,934
Zemlyane	Water Boiler 1	72	184	3,295
	Water Boiler 2	73	133	1,239
	Water Boiler 4	77	189	2,832
	Small Steam Boiler 1	79	131	
	Small Steam Boiler 2	74	84	
	Small Steam Boiler 3	71	111	
Lyulin	Water Boiler 1	71	202	394
	Water Boiler 2	95	70	
	Water Boiler 4	72	205	2,931

If new or existing boilers were required to evaluate/apply Best Available Techniques (BAT), the range of current BAT levels is presented in Table 2-2. Black & Veatch notes that the European Commission is currently drafting new BAT standards for large combustion plants, to be ready for vote in January 2022. Emission limits as directed by the EU are shown in Table 2-3. The values listed apply only to gas turbines functioning at above 70% load.

Table 2-2 Best Available Techniques-Associated Emission Levels for NOx Emissions from NG Combustion[1]

[1] European Union Industrial Emissions Directive (2010/75/EU)

Combustion Plant Type (Component)	BAT-AELs (mg/Nm³)			
	Annual Average		Daily Average	
	New Plant	Existing Plant	New Plant	Existing Plant
Boiler	10-60	50-100	30-85	85-100
Engine	20-75	20-100	55-85	55-110

Table 2-3 Emission Limits (NOx, CO) for Gas-Fired Combustion Plants[2]

Combustion Plant Type	Emission Limits (mg/Nm³)	
	NOx	CO
Gas Turbine (including CCGT)	50	100
Gas Engine	75	100
Other Combustion Plants	100	100

2.1.2 Reduce the Safety Risk for TSEAD

Much of TSEAD's existing equipment and infrastructure have aged or are aging beyond their useful life, which presents a safety risk to workers and has an adverse effect on operation. Black & Veatch conducted a site visit to the heating plants on 29 June through 1 July, 2021. Based on the aboveground visual observations made during the site visit, Black & Veatch is of the opinion that the condition of most of the plants is reflective of their age and therefore causes an increased risk of failure. Some of the pictures from the site visit are presented on Figures 2-1 and 2-2.

[2] Large Combustion Plant, Best Available Techniques (BAT) Conclusions: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1503383091262&uri=CELEX:32017D1442

Figure 2-1 Site Visit Pictures of Some Boilers

Figure 2-2 Site Visit Picture of Boiler Buildings and Piping

Black & Veatch was provided with inspection reports that outlined safety incident and employee injury data, along with common deficiencies at the plants. These reports cover inspections of the equipment and transportation vehicles at the DHRs and the distribution system. Other items covered by the inspection reports include safety training and employee safety.

A summary of the information provided is shown in Table 2-4. This includes the number of completed inspections and mandatory corrective actions between 2016 and 2020. Common causes for mandatory corrective actions are missing signage, missing personal protection equipment (PPE), and building structural issues. Building structural issues included floor cracks, openings, damaged heat insulations, building light issues, and missing safety signs. While the number of corrective actions were deemed acceptable by the inspectors, Black & Veatch notes the presence of building structural issues should be resolved to minimize the safety related risks.

The employee injury statistics were gathered from a report of data from January 2015 through August 2021. Out of the 35 recorded injuries, over 60 percent occurred on-site and included head injuries, back injuries from lifting, chemical poison, and broken limbs due to falls mainly at Sofia Central. While none of the injuries were fatal, the building at Sofia Central where the majority of the falls occurred appeared to be in deteriorating condition as noted during the site visit.

Table 2-4 Safety Incident Overview

Year	Completed Inspections	Mandatory Corrective Actions	% Actions/Inspections	Employee Injuries
2015	-	-	-	8
2016	80	139	174	6
2017	131	245	187	7
2018	76	94	124	6
2019	128	166	130	5
2020	139	159	114	3
2021	-	-	-	0

While the decreasing trend in the employee injury indicates a renewed focus from TSEAD management towards improving safety culture within the organization, Black & Veatch is of the opinion that the Plan should also address safety risk for TSEAD because majority of TSEAD's equipment and buildings appear to be in poor condition primarily due to age and underfunded maintenance and repair.

2.1.3 Increase in the Reliability for TSEAD Customers

From August 2 through August 9, 2021, repair works to Sofia East plant caused loss of hot water service to majority of TSEAD's Sofia East customers. Based on discussions with TSEAD, Black & Veatch understands that such occurrences are not uncommon. Besides the aging infrastructure, the current distribution system has limited interconnection capability between the major district heating plants, therefore during such outages only a limited number of customers get supply from the other heating plants while most other customers are left without hot water.

While outage data was not provided for the four large heating plants, the outage hours for Zemlyane over the past 10 years and the lost energy due to forced outage at Lyulin over the past 4 years are presented on Figure 2-3 and Figure 2-4 respectively. Lyulin data for 2021 is the expected value for the entire year based on the actual data through June. These provide indicative information that the number of repair hours and the amount of lost energy production due to forced outage has been increasing over time. While there appears to be adequate redundancy in the major equipment to minimize disruptions in the heat supply from outage of one or two equipment failure, based on the trends indicating increasing failure rate, it is probable that the redundancy will not be adequate in future.

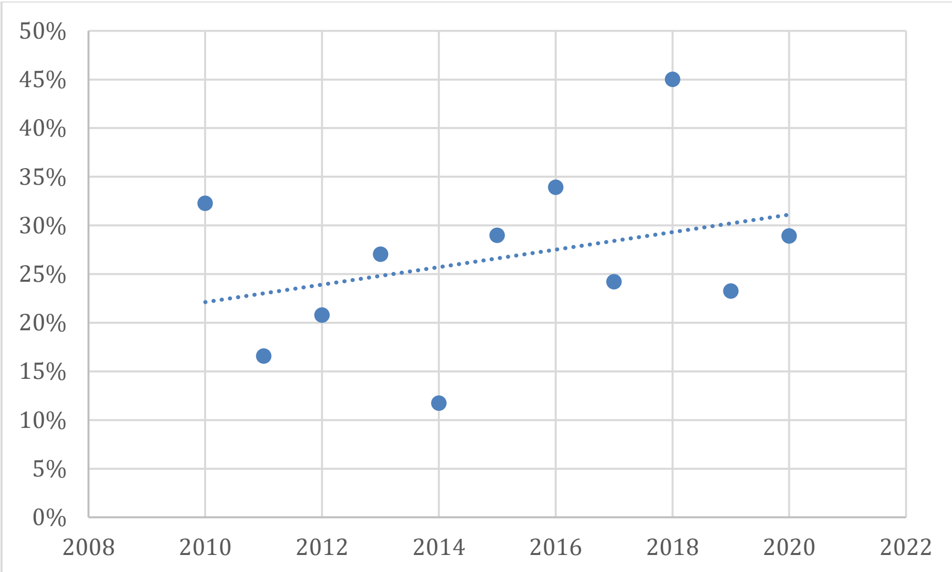


Figure 2-3 Annual Repair Hours as a Percentage of Operating Hours at Zemlyane

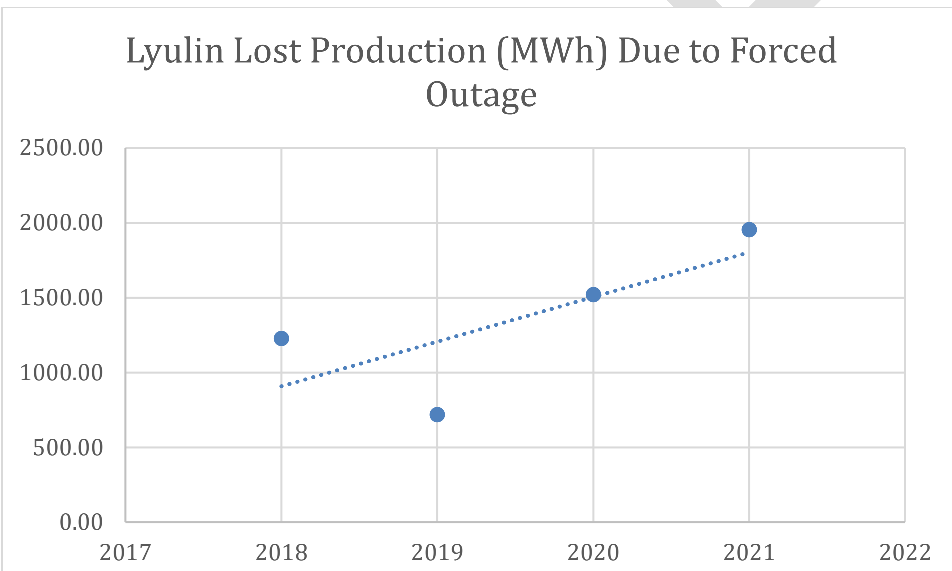


Figure 2-4 Lost Energy Production (MWh) Due to Forced Outage at Lyulin

Makeup water rates over the last 10 years due to losses in the heat distribution system is presented on Figure 2-5 as a sum of the four water plants. It can be seen that the quantity of makeup water has increased significantly over the last 10 years due to leakages in the distribution system.

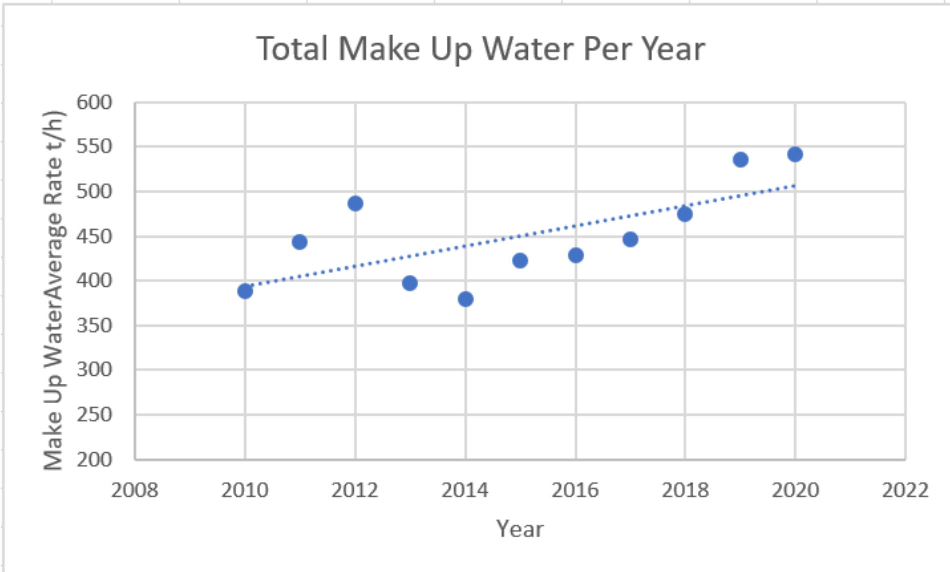


Figure 2-5 Aggregate Makeup Water Per Year

In general, both the generation systems and the distribution systems are contributing to the reduced reliability for TSEAD customers. Any improvement plan should not only be focused on improving the reliability of the district heating plants but also on the upgrades required for the distribution system to improve reliability of service.

2.1.4 Increase the Thermal and Electrical Efficiency of the District Heating Plants

Given the age of the equipment, the existing units are significantly deteriorated and were designed at lower efficiency standards. With modern installations, there exists an opportunity to significantly increase the efficiency of the heating plants and reduce overall fuel expenses, operating costs, and emissions.

2.1.5 Comply with Current and Planned EU GHG Emissions Requirements

One of the main objectives of the Plan is to help in Bulgaria's compliance with current and planned EU greenhouse gas (GHG) emission requirements. There are two main EU directives that are related to reduction of GHG.

1. Directive (EU) 2018/2002: The Directive 2018/2002 of the European Parliament and of the Council of 11 December 2018 amended Directive 2012/27 / EU on energy efficiency and sets a new target for 2030. The key element of the amended Directive is a non-binding energy efficiency target for 2030 of at least 32.5%. The directive allows for a possible upward revision in the target in 2023, in case of substantial cost reductions due to economic or technological developments. It also includes an extension to the energy savings obligation in end use, introduced in the 2012 directive. Under the amending directive, EU countries will have to achieve new energy savings of 0.8% each year of final energy consumption for the 2021-2030 period.

2. Directive (EU) 2018/410: This directive was adopted by the European Union on 14 March 2018 – and amends Directive 2003/87/EC on setting up a scheme for GHG emission

allowance trading (also known as Emissions Trading System, or EU ETS). In the context of the efforts undertaken by the EU to cut GHG emissions by at least 80% by 2050, the European Council agreed in October 2014 the 2030 policy framework for climate and energy. A centerpiece of this framework is the binding target to reduce overall EU emissions by at least 40% domestically below 1990 levels by 2030.

The GHG reduction for Bulgaria compared to 1990 values are presented in Figure 2-6, it can be seen that Bulgaria has already achieved the 40% reduction from 1990 level. However, Bulgaria remains as one of the EU countries where significant electrical generation comes from Coal plants. With the use of highly efficient cogeneration technology, national GHG emissions can be significantly reduced.

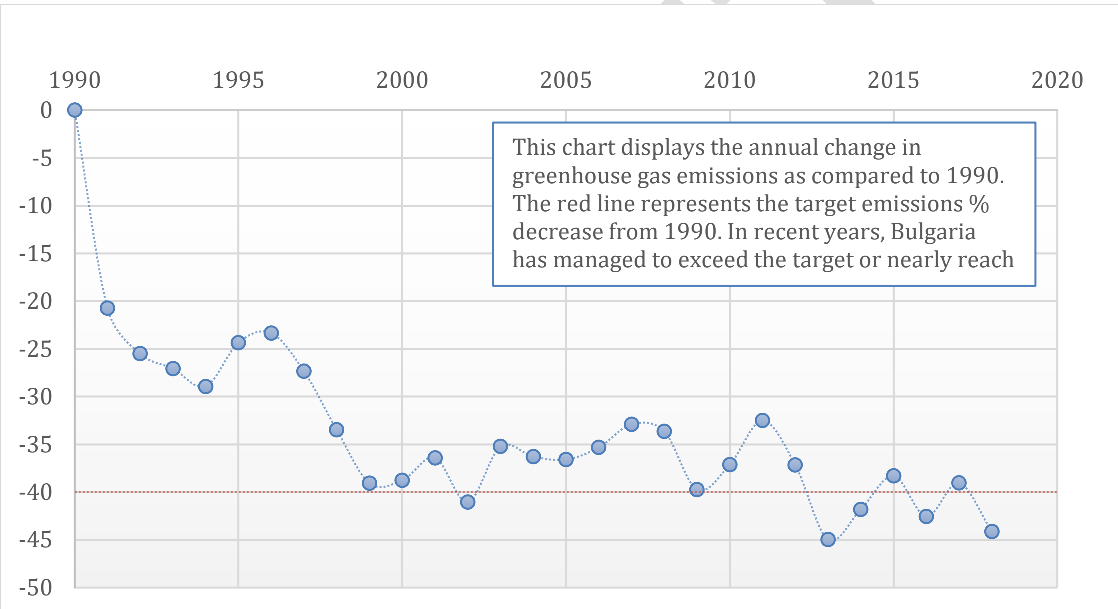


Figure 2-6 Annual Greenhouse Gas Emissions (% Change from 1990)[3,4]

2.1.6 Financial Stability of TSEAD

For the last several years, TSEAD has been operating at loss. TSEAD's financial losses for the last 2 years are presented in Table 2-10. A series of measures are needed to change the financial position and the ability to repay the current obligation.

Table 2-5 TSEAD Financial Losses (2019-2020)

Year	Losses (Million BGN)
2019	82.5

[3] For 1990-2012, World Bank staff estimates from original source: European Commission, Joint Research Centre (JRC)/Netherlands Environmental Assessment Agency (PBL). Emission Database for Global Atmospheric Research (EDGAR): edgar.jrc.ec.europa.eu.
[4] For 2012-2018, Annual greenhouse gas emissions of the energy sector in Bulgaria 2008-2018 Published by Statista Research Department, Jul 5, 2021

Year	Losses (Million BGN)
2020	67.2

2.1.7 End-of-Life Replacement for Majority of TSEAD Equipment

Any plan for long-term operation of TSEAD should consider that majority of TSEAD equipment is at or beyond the end of its designed useful life and therefore provide for appropriate replacement.

2.1.8 Plan for Expansion Over the 20 Year Program Life

There has been a steady trend in recent years for increasing the clients of TSEAD, which is a sign that the company is providing a competitive service. According to TSEAD, taking into account that the district heating is potentially among the most environmentally friendly, efficient and comfortable methods for heating a justified forecast for the continuation of this tendency in the future can be made, especially if system reliability is improved. TSEAD expects about 15 percent growth in customers over the next 20 years.

Table 1-6 TSEAD Customer Growth in Recent Years

Number of Customers of Heat Energy	2017	2018	2019	2020
Households	407987	409967	411957	415126
Companies	31959	32521	33093	33434
State budget companies	2387	2414	2441	2550
Total	**442333**	**444902**	**447491**	**451110**

3.0 Assessment of 2019 Report Technical Recommendations and Plan Development

In order to develop the Plan, Black & Veatch reviewed plant design and operating information provided by TSEAD along with the 2019 Report. Black & Veatch also reviewed another report similar to the 2019 Report shared by TSEAD. This report titled "Analysis of investment in cogeneration modules based on gas turbines and gas-piston engines at Toplofikacia Sofia EAD" (Cogen Report) was submitted in August 2019 to the supervisory board of TSEAD.

3.1 Technical Recommendations in the 2019 Report

This subsection summarizes the technical recommendations made in the 2019 Report.

The 2019 Report recommends the construction of four cogeneration facilities located at the Lyulin, Zemlyane, Sofia, and Sofia East sites, with a total installed electric capacity of 307.4 MWe (Project). The Project includes construction of 1x1 cogeneration facilities at each Lyulin (43.2 MWe), Zemlyane (72.2 MWe), Sofia Central (43.2 MWe) and construction of a 2x1 cogeneration facility at Sofia East (148.0 MWe). Construction of the Project is assumed to be completed in two stages with construction of Lyulin and Zemlyane in stage 1 and construction of Sofia TPP and Sofia East TPP in stage 2.

A summary of the major equipment counts, installed capacities, and expected annual production for each of the facilities within the Project is provided in Table 3-1.

Table 3-1 Summary of 2019 Report Recommended Project Capacities and Expected Production

Plant	Major Equipment			Installed Electric Capacity (MWe)			Gross Capacity at 15° C		Expected Annual Production	
	Gas Turbine	HRSG	Steam Turbine	Gas Turbine	Steam Turbine	Total	Electric (MWe)	Thermal (MWt)	Electricity (MWhe)	Thermal (MWht)
1st Stage										
Lyulin	1	1	1	31.2	12.0	43.2	41.4	35.6	865,000	703,000
Zemlyane	1	1	1	54.0	19.0	73.0	72.2	53.5		
2nd Stage										
Sofia	1	1	1	31.2	12.0	43.2	41.4	35.6	1,452,000	1,157,000
Sofia East	2	2	1	108.0	40.0	148.0	144.4	107.0		
Total	**5**	**5**	**4**	**224**	**83.0**	**307.4**	**299.4**	**231.6**	**2,317,000**	**1,860,000**

The cogeneration facilities include major equipment such as gas turbines, heat recovery steam generators (HRSGs), and steam turbines with the quantities located as each site specified in Table 3-1. However, each facility also includes associated balance of plant (BOP) equipment such as transformers, natural gas compressors (not included for Lyulin as a new gas interconnection is assumed to be installed), water treatment equipment, and other required supporting equipment and materials.

The 2019 Report indicates that the configurations and capacities of the facilities were determined to maintain the historical heating energy production (based on 2017 and 2018 data), but increase the electricity production due to the potential of selling excess electricity on the free market. Lyulin, Zemplyane, and Sofia East are assumed to be baseload facilities, operating 24/7 with the exception of two weeks of planned outages per year to accommodate scheduled maintenance. The 2019 Report assumes that the refuse-derived fuel (RDF) project and Sofia TPP will be operated jointly. Sofia TPP is assumed to be dispatched after the RDF facility during the heating season and to share the load with the RDF facility (proportionate to their respective heating capabilities) during the non-heating season.

3.2 Technical Recommendations in the Cogen Report

This section summarizes the technical recommendations made in the Cogen Report.

A summary of the major equipment counts, installed capacities, and expected annual production for each of the facilities within the Project is provided in Table 2-2.

Table 3-2 Summary of Cogen Report Recommended Project Capacities and Expected Production

Plant	Major Equipment			Installed Electric Capacity (MWe)			Gross Capacity at 15° C		Expected Annual Production	
	Gas-piston Engines	Gas Turbine	Steam Turbine	Gas Turbine	Steam Turbine	Total	Electric (MWe)	Thermal (MWt)	Electricity (MWhe)	Thermal (MWht)
Lyulin	0	1	1	31.2	10.0	41.2	38.1	36.6	2,961,438	3,675,744
Zemlyane	0	1	1	47.5	14.0	61.5	59.1	52.8		
Sofia	0	2	1	114.0	35.0	149.0	147.0	125.4		
Sofia East	0	2	1	114.0	40.0	154.0	146.4	126.1		
HOB Ovcha Kupel 1 and 2	3	0	0	10	0	10	10	9.6		
HOB Hadji Dimitar	2	0	0	7	0	7	7	6.7		
HOB Levski G	1	0	0	3.5	0	3.5	3.5	3.4		
Total	**6**	**6**	**4**	**327.2**	**99.0**	**426.2**	**411.1**	**360.6**		

The facilities selected detail the power outputs required to maintain heat energy production due to the specifics of the heat energy market. The heat outputs provided are recorded using the selected equipment, operating mode, and outside temperature specified and when the steam turbine is powered only by the heat recovery boilers.

3.3 Identified Gaps in the 2019 Report and the Cogen Report

Black & Veatch identified areas of the 2019 Report and the Cogen Report that require further due diligence. These items are outlined below:

- *Neither the 2019 Report nor the Cogen Report addresses the deteriorating hot water distribution infrastructure.* The distribution system is old, lacks necessary interconnection to provide service reliability, and has not been maintained due to lack of funds. TSEAD estimates significant capex will be required to keep the distribution system reliable. There is no budget allocation in these reports for distribution system.

- *The age of existing equipment, specifically boilers, is not considered*. Majority of the equipment at the CHP and heating plants is near or beyond the typical useful life for such equipment. The 2019 Report and Cogen Report discuss plans for cogeneration installations at the plants, with the idea of continuing to use existing equipment for another 20 years, but it does not consider the age of this equipment. Specifically, regarding boilers, their retirements were not discussed in the study, even though the majority of the units exceeded their typical useful life of 30 to 40 years. This would have an impact on plant reliability, while causing TSEAD to incur high costs of maintenance to keep the aging boilers running. No additional Capex for life extension was considered in these reports.
- *NOx emissions exceed EU emission limits and their penalty costs are not included.* In addition to exceeding their technical life, the boilers do not meet their NOx requirements. The emissions limit in Europe is currently 100 [mg/Nm^3]. To date TSEAD has incurred significant penalties for exceeding EU's NOx limit and faces further substantial fines in the future unless the problem is fully addressed.
- *Local issues with installing cogeneration plants at Sofia Central and Zemlyane not considered*. No consideration has been provided in the 2019 Report or the Cogen Report to the planned cogeneration being proximate to large and expanding residential complexes at Sofia Central and Zemlyane, posing immediate and long term localized environmental issues. In addition at Sofia Central, no consideration has been provided to the overlap in construction with the RDF plant.
- *Grid interconnection costs from additional generation not considered.* The additional generation that will be added at these sites from these installations will yield grid interconnection costs that have not been discussed in the study.
- *Future growth projects not considered.* 2019 Report and Cogen Report assumes the heating production to remain at historical levels. Cogen Report analyzed the heat load from 2013 through 2018 and noted an increase in the number of customers for TSEAD but did not find a good correlation between the increase in the number of customers and the heat load. The Cogen Report assigned the lack of clear trend to possible energy efficiency measures and therefore choose to keep the heat load equal to the 2018 level. Black & Veatch notes a key gap in this analysis was not considering the average temperature during winter months and therefore a trend with customer growth may not have been evident. Black & Veatch analyzed the load data with the temperature and found a strong correlation of heat load with the ambient temperature which should not have been ignored.

Table 3-3 Comparison of Heat Loads from 2014 through 2018

Plant	2014	2015	2016	2017	2018
Average Winter Temperature (Jan, Feb, Mar, Nov and Dec)- Degree C	4.508	2.874	2.898	2.044	3.076
Heat Load	3,576,529	3,828,965	3,718,201	3,844,682	3,703,274

3.4 Baseline for Performance Measurement

Black & Veatch has only received part of the data for year 2020, therefore baseline for the thermal performance measurement is based on 2018 performance data as presented in Cogen Report. Average winter temperature for 2018 as noted in closely matches the mean temperature of 3.056 degree C and therefore appears to be a reasonable choice for establishing base demand. Based on the operating data provided by TSEAD, Black & Veatch verified that year 2020 heat load closely matched the 2018 heat load for Sofia Central, Zemlyane, and Lyulin. The comparison is presented in Table 3-3. 2020 heat load data was not available for Sofia East. Baseline performance is presented in Table 3-4.

Table 3-4 Comparison of 2018 and 2020 Actual Heat Loads

Plant	Heat Load (2018)	Heat Load (2020)	Ratio (2020/2018)
Sofia Central	1,389,467	1306368	94%
Zemylane	753,963	743594	99%
Lyulin	449,859	427766	95%

Table 3-5 Baseline Performance 2018

Month		2018 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2018 Total
Days		31	28	31	30	31	30	31	31	30	31	30	31	365
TECHNICAL PARAMETERS														
I. ELECTRICAL ENERGY		**2018 Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**2018 Total**
4 Electricity-gross production	**MWh**	**116,195**	**112,042**	**112,076**	**56,544**	**41,445**	**38,354**	**38,778**	**31,193**	**44,760**	**53,847**	**84,714**	**109,018**	**838,966**
6 Own needs - Total	**MWh**	**20,896**	**18,735**	**18,986**	**10,371**	**8,005**	**7,723**	**7,126**	**5,232**	**7,288**	**8,663**	**14,774**	**21,161**	**148,960**
	%	18.0%	16.7%	16.9%	18.3%	19.3%	20.1%	18.4%	16.8%	16.3%	16.1%	17.4%	19.4%	17.76%
7 Transformation losses	**MWh**	**1,494**	**1,681**	**1,413**	**778**	**569**	**675**	**651**	**684**	**943**	**1,088**	**1,389**	**1,476**	**12,841**
	%	1.6%	1.8%	1.5%	1.7%	1.7%	2.2%	2.1%	2.6%	2.5%	2.4%	2.0%	1.7%	1.9%
8 El. Energy for realisation	**MWh**	**93,805**	**91,626**	**91,677**	**45,395**	**32,871**	**29,956**	**31,001**	**25,277**	**36,529**	**44,096**	**68,551**	**86,381**	**677,165**
II. HEAT ENERGY														
1 Produced Heat Energy	**MWh**	**761,716**	**667,139**	**618,713**	**259,370**	**184,477**	**172,848**	**162,783**	**149,418**	**169,367**	**203,429**	**515,163**	**795,790**	**4,660,213**
1.1. for Heat supply	MWh	748,209	654,920	606,727	254,766	181,984	170,823	160,834	148,203	167,072	200,093	506,953	784,300	4,584,884
1.2. Own needs	MWh	13,508	12,219	11,985	4,603	2,493	2,025	1,949	1,216	2,295	3,337	8,210	11,491	75,331
	%	1.8%	1.8%	1.9%	1.8%	1.4%	1.2%	1.2%	0.8%	1.4%	1.6%	1.6%	1.4%	1.6%
2 Heat supply	**MWh**	**748,209**	**654,920**	**606,727**	**254,766**	**181,984**	**170,823**	**160,834**	**148,203**	**167,072**	**200,093**	**506,953**	**784,300**	**4,584,884**
3 Heat losses	**MWh**	**86,189**	**86,465**	**79,663**	**62,349**	**62,431**	**62,751**	**63,164**	**58,992**	**63,757**	**70,110**	**96,835**	**88,903**	**881,609**
	%	11.3%	13.0%	12.9%	24.0%	33.8%	36.3%	38.8%	39.5%	37.6%	34.5%	18.8%	11.2%	19.2%
4 Heat enrgy for realization	**MWh**	**662,020**	**568,455**	**527,064**	**192,417**	**119,553**	**108,072**	**97,670**	**89,211**	**103,315**	**129,983**	**410,118**	**695,397**	**3,703,275**
III. Consumed Natural Gas														
1 Natural Gas	**MWh**	**998,821**	**898,781**	**850,872**	**367,868**	**257,575**	**240,011**	**235,964**	**205,864**	**246,733**	**292,932**	**683,322**	**1,027,339**	**6,306,082**
Average CV	kJ/Nm^3	34,500	34,500	34,500	34,500	34,500	34,500	34,500	34,500	34,500	34,500	34,500	34,500	34,500
	$tho.Nm^3$	104,225	93,786	88,787	38,386	26,877	25,045	24,622	21,481	25,746	30,567	71,303	107,201	658,026
IV. CO2 emissions emitted from production														
1 Natural Gas	**t CO2**	**200,053**	**180,016**	**170,421**	**73,680**	**51,590**	**48,072**	**47,261**	**41,232**	**49,418**	**58,671**	**136,862**	**205,765**	**1,263,041**
VI. Plant Efficiency														
Net electrical efficiency (after considering electricity purchase)	%	8.4%	9.3%	9.8%	11.5%	12.1%	12.0%	12.5%	10.6%	12.4%	14.3%	9.1%	7.5%	9.8%
Net heat efficiency (LHV)	%	74.9%	72.9%	71.3%	69.3%	70.7%	71.2%	68.2%	72.0%	67.7%	68.3%	74.2%	76.3%	72.7%
Total efficiency of the plants (LHV)	%	84.3%	83.1%	82.1%	81.6%	83.4%	83.7%	81.3%	84.3%	82.5%	83.4%	84.2%	84.8%	83.4%

4.0 Plan Description

Given the scale of TSEAD's current operational and financial deficiencies, Black & Veatch believes it is imperative that the Plan provide substantial and comprehensive remediation. This section discusses the initial Plan parameters and recommendations and identifies specific projects to achieve the Plan objectives, which are as follows:

1. According to the Industrial Emissions Directive 2010/75/EU, ensure that all boilers are to meet a NO_X emission limit of 100 mg/Nm^3.
2. Reduce the safety risk for TSEAD workers.
3. Increase heat reliability for TSEAD customers.
4. Increase the thermal and electrical efficiency for TSEAD's district heating plants.
5. Comply with current and planned EU GHG emissions requirements to improve energy efficiency and reduce GHG emissions by 80% by 2050 and by 40% of 1990 levels by 2040.
6. Provide for sustainable financial stability of TSEAD by increasing electricity revenues.
7. Address end-of-life replacement of aging TSEAD equipment.
8. Plan for Expansion over a 20 year program life

Black & Veatch understands that the waste-to-energy combined heat and power (WECHP) project, producing refuse-derived fuel (RDF), which is converted to heat and electrical power, is currently under development. Based on the objectives summarized above and described in Section 2.0, the Plan comprises the following three key steps:

1. *Distribution System Upgrade*: The existing hot water distribution system has leaks in its aging sections, is choked in places due to insufficient pipe size and flow capacity, and is largely radial in design. Each of these is a serious impediment to reliable service.

   The result of leaking pipes is that they lose hot water causing reduced efficiency. Losses have reached the level of 19% annually, well above levels of similar district heating systems, and a significant drain on revenues.

   The result of insufficient pipe size is that when a district heating plant is suffering an outage, other plants cannot deliver the full capacity to serve the load.

   The result of radial design is that when maintenance needs to be performed along one of the radial feeds, the customers downstream of the repair area do not receive service as there is no accessible alternative source of heat supply. Installation of a city-wide loop design will allow heat to be provided to the entire system from multiple sources, thereby substantially reducing service interruptions.

   Overall, corrections to these problems directly addresses Objectives 3, 5, 7, and 8.

2. *New Cogeneration Plant and Upgrades to Existing Plants*: The existing district heating plants are aging and in some cases in need of replacements. With age, down time is increasingly frequent causing more frequent interruptions in service. Aging and inefficient technology causes increased fuel usage leading to increased NO_x and GHG emissions. Replacing antiquated bottoming cycle technology can offer a far greater amount of electric power generation at high efficiency, thereby substantially increasing revenue to TSEAD. Finally, the aging facilities with rusting and crumbling structures have become unsafe in places for workers. Corrections to these

problems by installing new highly efficient and high power producing cogeneration plants directly addresses Objectives 1, 2, 3, 4, 5, 6, and 7.

3. *New Boilers and NO_x Emission Reduction Upgrades to Existing Boilers*: The proposed cogeneration is sized to serve summer loads with minimum throttling. Such size will require reliance upon new and upgraded boilers to supplement the cogeneration plant for serving the peak winter thermal demands. The capacity of the boilers would also account for heating demand growth projected in Sofia over the coming years. This strategy directly addresses Objectives 1, 2, 3, 4, 5, 6, 7, and 8.

Each of these key Plan components is described in this section. In combination they will result in a TSEAD that is more reliable, solvent and environmentally compliant.

4.1 WECHP Project

Sofia Municipality began implementing a household waste management program in 2014. The first two phases of the plan involved construction of waste disposal and sorting facilities and construction of a mechanical biological treatment (MBT) facility that produces biomass and refuse-derived fuel (RDF) suitable for combustion. Phase 3 is intended to construct a cogeneration facility by TSEAD which can be fueled by the RDF produced from the MBT (referred to hereafter as RDF plant or waste to energy combined heat and power (WECHP) plant). The RDF facility is currently anticipated to be located at the Sofia TPP site. We note that the proposed Plan assumes, but does not rely upon, WECHP project completion.

4.1.1 Expected Operational and Financial Impact of the WECHP Plant

Black & Veatch reviewed TSEAD's Technical Financial Model, which includes projections associated with the RDF plant through 2038 such as fuel use, electricity and heat energy production, operating costs, and construction capital expenditures. This subsection summarizes these projections.

The RDF plant, currently anticipated to be located at the Sofia TPP site, is projected to utilize approximately 162,000 tons of RDF anticipated to be produced by the MBT annually to produce an estimated 105,000 MWhe of electricity and 377,000 MWht of thermal energy annually. Operation of the RDF plant is projected to offset use of approximately 65 million Nm^3 of natural gas annually.

The RDF plant is projected by TSEAD to cost approximately €157.5 million total, exclusive of any applicable value-added tax (VAT). Table 4-1 summarizes the RDF plant projected construction capital expenditures.

Table 4-1 Summary of RDF Construction Cost

Category	Cost (million €)
Equipment	125.0
Civil Works	17.5
Approach Infrastructure	3.0
Site Prep and Safety	0.6
Project Management	8.4
Contingency	3.0

Category	Cost (million €)
Total	**157.5**

The Technical Financial Model includes the following operating cost categories specifically identified for the RDF plant: materials for repair, cost of external services, consumables, and salaries. The Technical Financial Model also includes other operating costs that are presented for the entire TSEAD operation and not specifically allocated to individual plants such as water, purchased electricity, insurance, legal, social security costs, etc. Figure 4-1 shows the RDF plant operating costs included in the Technical Financial Model.

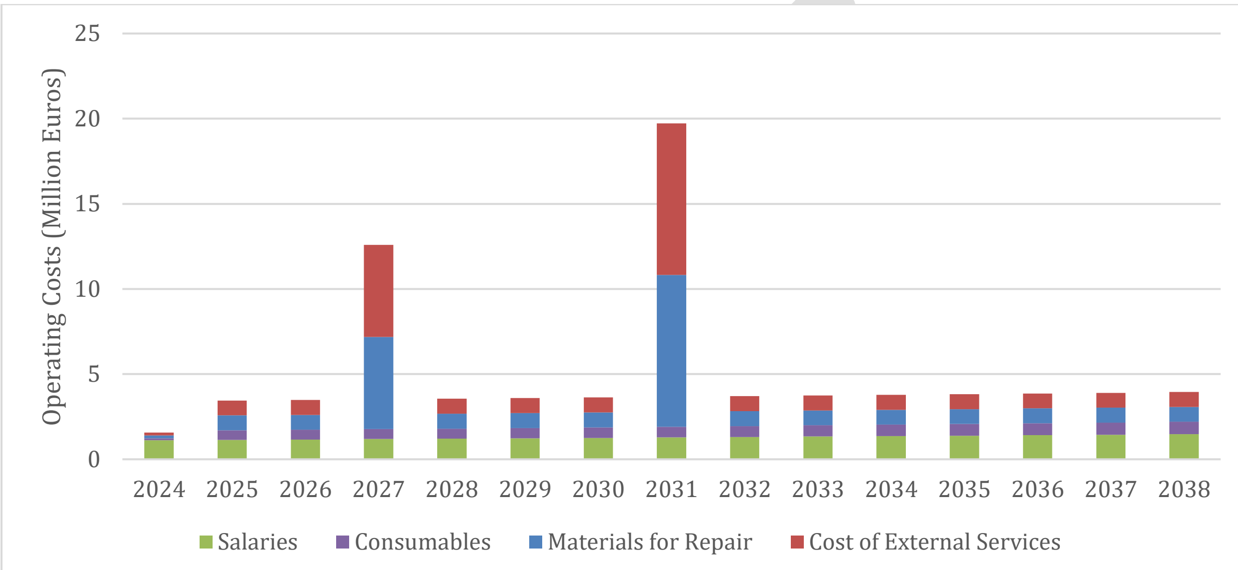


Figure 4-1 RDF Technical Financial Model Operating Costs (€ Millions)

4.2 Upgrades and Refurbishment of the Distribution Infrastructure

This subsection assesses the design and current condition of distribution infrastructure and identifies proposed improvements by TSEAD.

The existing district heating distribution system consists of approximately 1,080 km of piping, including 185 km of main pipelines (400 to 1200 mm diameter) and approximately 895 km of district pipelines (50 to 350 mm diameter).

Between 2001 and 2020, approximately 229 km of distribution piping was replaced, an average of 11.5 km per year. However, this level of replacements has not been sufficient to maintain the distribution system in good reliable and functioning condition. Based on discussions during the site visits, much of the distribution system piping has exceeded its expected useful life and is susceptible to leaks and outages. Additionally, TSEAD reported historical heat losses of 19.2 percent in 2018 and 20.9 percent in 2019, which is high based on Black & Veatch's experience with district energy systems. These excessive losses likely due to thermal losses associated with legacy piping designs/materials as well as leakage losses of hot water due to aging infrastructure. A target for future losses should be 15% or lower.

TSEAD has developed a 10 year (2022-2031) rehabilitation plan consisting of 54 km of annual pipeline replacements and six new pumping stations to address deferred replacements. Through this rehabilitation plan, approximately 76 percent of the existing main pipelines, 45 percent of the district pipelines, and 83 percent of the substations will be addressed. Beginning in 2032, TSEAD plans to replace 29 km of distribution piping and 720 substations annually, which is a replacement rate intended to maintain the condition of the distribution system. This replacement rate assumes useful lives of the main and district pipelines of at least 45 and 35 years, respectively and the pumping stations of at least 25 years. Figure 4-2 shows such an increase in replacement activity should help to reduce losses and improve system reliability. TSEAD's historical and planned annual distribution system pipeline replacements in kilometers.

Figure 4-2 Historical vs Planned District Heating Distribution System Replacements (km)

Most of TSEAD's existing distribution system is of a radial design, which can result in lower levels of reliability as the pipelines cause single points of failure to interrupt service. Such a design may lead to excessive service interruptions for two reasons.

First, if the heat plant connected to that radial shuts down for either planned or unplanned repairs, there is no way to supply heat to customers served by that radial from another source. And second, in the case of a needed repair on the radial itself, all customers beyond the point of repair lose their service for the same reason. The solution to both of these recurring causes of service interruptions is the creation of a city-wide loop which can be supplied from multiple sources.

Through hydraulic modeling of the system, TSEAD developed a plan for new network links to create such a loop. This plan includes 26.95 km of new and 17.62 km of reconstructed pipes lines to create a looped distribution system, where feasible, such that a pipeline failure will not result in large numbers of customer outages. In major branches of the distribution system where looping is infeasible, peaking boilers have been added to the plan to be located at the furthest reaches of the branches allowing service to be provided from two directions such that a pipeline failure will not result in large numbers of customer outages. The plan also includes new pump stations to further improve hydraulic characteristics of the system, especially in areas with higher elevations as on the south side of the city.

Figure 4-3 shows a map of the TSEAD distribution system planned improvements and Table 4-2 summarizes the scope of the planned improvements, and the creation of a large loop. Existing pipes are green, reconstructed pipes are blue, and new pipes are red. Black & Veatch notes that while the approach for adding additional piping and pump station appears reasonable, the hydraulic analysis should be updated based on the boiler locations proposed in the Plan.

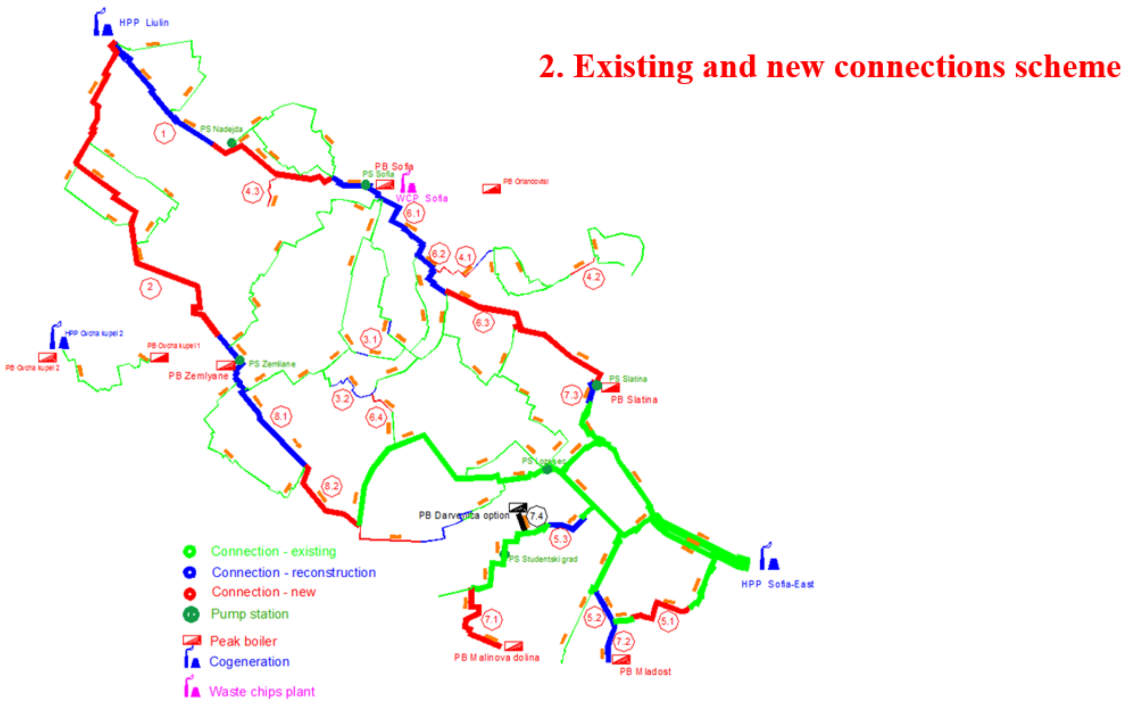


Figure 4-3 TSEAD Distribution System Planned Improvements Map

Table 4-2 TSEAD Distribution System Planned Improvements Summary

Category	Unit	Purpose
New/Reconstructed Connections	**44.57 km**	
Liulin – Sofia	6.70 km	Transfer max heat load from Sofia Central to Liulin
Liulin - Zemliane	10.00 km	Transfer max heat load from Zemliane to Liulin
Sofia - Zemliane	1.65 km	Stop Zemliane in the summer
Sofia - Pick Boilers islands	4.20 km	Connect heat only boiler areas to Sofia and stop boilers
Sofia East	2.70 km	Sofia East area hydraulics
Sofia - Sofia East	8.07 km	Feed Sofia East/Sofia during winter/summer breakdown
New Peak Boilers	3.80 km	Connect peak boilers to main system
Zemliane - Sofia East	7.45 km	Transfer heat loaf from Zemliane to Sofia East
New Pump Stations	**4,800 kW**	
PS Nadejda	800 kW	Reconstruction, Nadejda branch hydraulics
PS Lozenec	1,000 kW	Reconstruction, Lozenec branch hydraulics

Category	Unit	Purpose
PS Studentski grad	800 kW	New, Studentski grad branch hydraulics
PS Slatina (built in PB Slatina)	600 kW	New, Slatina grad branch hydraulics
PS Sofia - return	800 kW	Reconstruction, flatten return pressure
PS Zemliane – supply	**800 kW**	**Reconstruction, flatten supply pressure**

4.3 New Cogeneration Plants

4.3.1 General Discussion on Cogeneration Efficiency

TSEAD requires a well-balanced cogeneration capacity which will maximize efficiency and electric power generating capacity while reliably serving all the thermal loads of the city of Sofia. Maximizing efficiency requires flue gas stack temperatures to be minimized by using every means to extract heat from it before discharging to atmosphere. Additionally, maximizing efficiency demands minimal heat rejection equipment in the process.

Efficiency is not the total answer where there are two types of energy loads to be served simultaneously, as is done with cogeneration systems. Where both electric power and thermal loads are to be served, serving them effectively and efficiently requires a review of cogeneration options—and there are several—and selection of the right cogeneration technology. In any cogeneration application, the best electrical power generating output and efficiency are achieved by selection of a cogeneration technology which balances electric power and thermal generating capacity against the electric power and thermal loads. For TSEAD, there are well-documented thermal loads to be satisfied at all times, but the electric loads may be served by the cogeneration plant, or the electrical power grid, or both. This means that thermal loads must be satisfied at all times, while electric loads do not have to be satisfied strictly by the cogeneration plant. However, as one of TSEAD’s objectives is to optimize revenue, the strategy to achieving that objective is to select a cogeneration technology option to maximize efficient electric power generating capacity while producing only the thermal output needed to serve the thermal loads.

A review of cogenerating technologies reveals their weaknesses and strengths in both efficiencies and capacities. A steam Rankine Cycle system, utilizing boilers and back pressure steam turbine generators with exhaust steam heat recovery, is a bottoming cycle for power generation, meaning, heat is produced first in the boiler, or at the top of the cycle, and electricity is produced through the steam turbine at the end or bottom of the cycle. This system produces power at an efficiency of about 25%, meaning that 75% of the energy is converted to heat that must be ejected from the system for the cycle to function. If all of that heat is to be used, which would make the cogeneration system efficient, the heat load needs to be three times more than the electric power that is produced. Rankine Cycle systems served communities very well for decades in northern climates where electric power loads were low and where thermal loads for winter heating were much higher. In the current age of electronics and communications, data centers and sophisticated laboratory equipment, air conditioning and increasingly electrified transportation, the balance of thermal to electric loads have been rapidly shifting more toward electric power demands. As electric loads have increased and thermal loads have remained the same or decreased, the traditional steam Rankine Cycle systems are therefore not providing the best energy balance anymore for cogeneration.

Combustion turbine and reciprocating internal combustion engine generators with heat recovery are examples of topping cycles, which produce electricity first at the top of the cycle followed by heat generated in the process for capture at the bottom. These systems produce power at efficiencies approaching 40%, meaning that the heat load needs to be between two and one and a half times more than the electric power that may be efficiently produced. These technologies are providing a better balance for increasing electric loads for cogeneration systems.

However, where electric loads can be as high as the electric power grid can receive it, there is a better technology available. A combined cycle system utilizing combustion turbines, heat recovery steam generators, and back pressure steam turbine generators with exhaust steam heat recovery, produces electric power at efficiencies approaching 50%, meaning that the combined cycle system can produce nearly the same amount of electric power and heat. This is called a combined cycle because it produces electricity at both the top and the bottom of the cycle, thereby efficiently generating the most electricity for a given amount of fuel, and heat production is minimized. Given TSEAD's desire to produce as much electricity as possible while efficiently serving the thermal loads of Sofia, a combined cycle cogeneration system was chosen as the technology option to serve TSEAD.

The urgent problem of excessive NOx emissions is discussed above. TSEAD also desires a system that produces a minimum of greenhouse gas emissions. The most common greenhouse gas is carbon dioxide (CO_2). It is generated and emitted from combustion processes fueled with any fossil fuel, because all fossil fuels have carbon in them. However, all fossil fuels are not alike in this regard. Coal generates 325 kg of CO_2 per MW hour of fuel burned, while natural gas generates 181 kg of CO_2 per MW hour of fuel burned. Natural gas is the lowest CO_2 emitting fossil fuel of all carbon based fuels. Therefore, one way to reduce CO_2 emissions is to use natural gas in place of coal or oil. TSEAD has already replaced coal with natural gas in all its thermal processes. Another way to reduce CO_2 emissions is to use fuel as efficiently as possible.

By maximizing efficiency at the district heating plants, fuel consumption is minimized, and resulting CO_2 emissions from TSEAD are also minimized. By maximizing efficient electric power generation, the city of Sofia will demand less electric power from existing coal fueled power plants serving the region resulting in a great reduction of CO_2 emissions overall.

There are some specifics to include in the design criteria in order to obtain the most efficient and the least heat producing combined cycle cogeneration plant. Highest efficiency is achieved by capturing as much heat as possible from the electric power generating process for use by the hot water distribution system. This requires careful electric power generating cycle design. The heat in the flue gas from the turbine is captured in a heat recovery steam generator (HRSG), utilizing stages of boiler feed water preheating starting at the outlet where the flue gas is coolest, then to the boiling section in the middle, and finally to the superheating section at the inlet where the flue gas is hottest and where superheated steam may be hottest. A boiler feed water preheating economizer is utilized at the back where the flue gas leaves the HRSG, and for hot water district heating systems, district hot water is preheated in a heat exchanger after that to enable practical extraction of all available heat in the flue gas, therefore minimizing fuel gas stack temperature and associated heat loss.

Next is the design of the steam turbine generator. The steam turbine generator is to be a back pressure unit, meaning, there are no cooling towers or other heat rejection equipment for condensing exhaust steam with atmospheric air, except minimally as needed to facilitate practical plant operations. All steam turbine back pressure steam is to be exhausted through a heat exchanger in which the steam is condensed while heating the district heating system water. The cogeneration plant can only operate at a capacity to serve thermal loads, therefore, the cogeneration plant is designed to be dispatched based on the instantaneous thermal demands of the district heating system.

This design also provides the benefit of minimizing water consumption. In traditional Rankine Cycle power plants, not designed for cogeneration, the steam exhausted from the steam turbine is exhausted at the coolest practical temperature to maximize power generation. Achieving the coolest temperature is done with evaporative cooling towers which take advantage of ambient air wet bulb temperatures which are usually lower than dry bulb temperatures. However, evaporation uses water to make up for the evaporated water. Additionally, evaporated water concentrates dissolved solids in the liquid water left behind, and excessive solids buildup over time builds up on surfaces leading to scaling and corrosion. Limiting the concentration of solids requires additional water to be drained to waste. Therefore, a properly designed efficient cogeneration system uses heat loads to remove heat from the electrical power production cycle and does not use cooling towers which waste heat and water and add a load to wastewater handling and treatment utilities.

Finally, lowest heat producing combined cycle plants begin with a best-in-class combustion turbine chosen for maximum power generation efficiency. High efficiency in power generation means less fuel used to produce the electrical power, and that means less heat produced in the process. The specific plan for the cogeneration plants is described in the next section.

4.3.2 Cogeneration Plan

Two new cogeneration plants are proposed to increase TSEAD's electrical power generating capacity and doing so at the highest overall efficiency while emitting a minimum of CO_2. The two cogeneration plants are to be identical in design. One would be located at the Sofia East site, and the other at the Lyulin site. Sofia Central and Zemlyane were not considered because of proximate to large and expanding residential complexes which may pose immediate and long term localized environmental issues. In addition, the ease of connection with the electric grid at Sofia East and Lyulin also influenced the choice of selecting these two locations for the cogeneration plant.

Each plant is sized to produce 240 MWe net, for a total TSEAD new cogeneration electric power production capacity of 480 MWe net. Each plant will also be able to produce 240 MWt to serve the thermal load of the district heating system. Each cogeneration plant is to be configured on a 2 on 1 basis, meaning two combustion turbine generators, each exhausting its heat through an HRSG, and the steam from both HRSGs will be delivered to a single backpressure steam turbine generator. Combustion turbine generators would be selected for providing between 80 and 100 MWe, and the back pressure steam turbine generator would be selected for providing an additional 40 to 80 MWe. Refer to Figure 4-4 for the cogeneration Process Flow Diagram. Though one combustion turbine and HRSG are shown on the diagram, two are proposed to operate in parallel. Also, this diagram applies equally to both cogeneration plants proposed.

Cogeneration

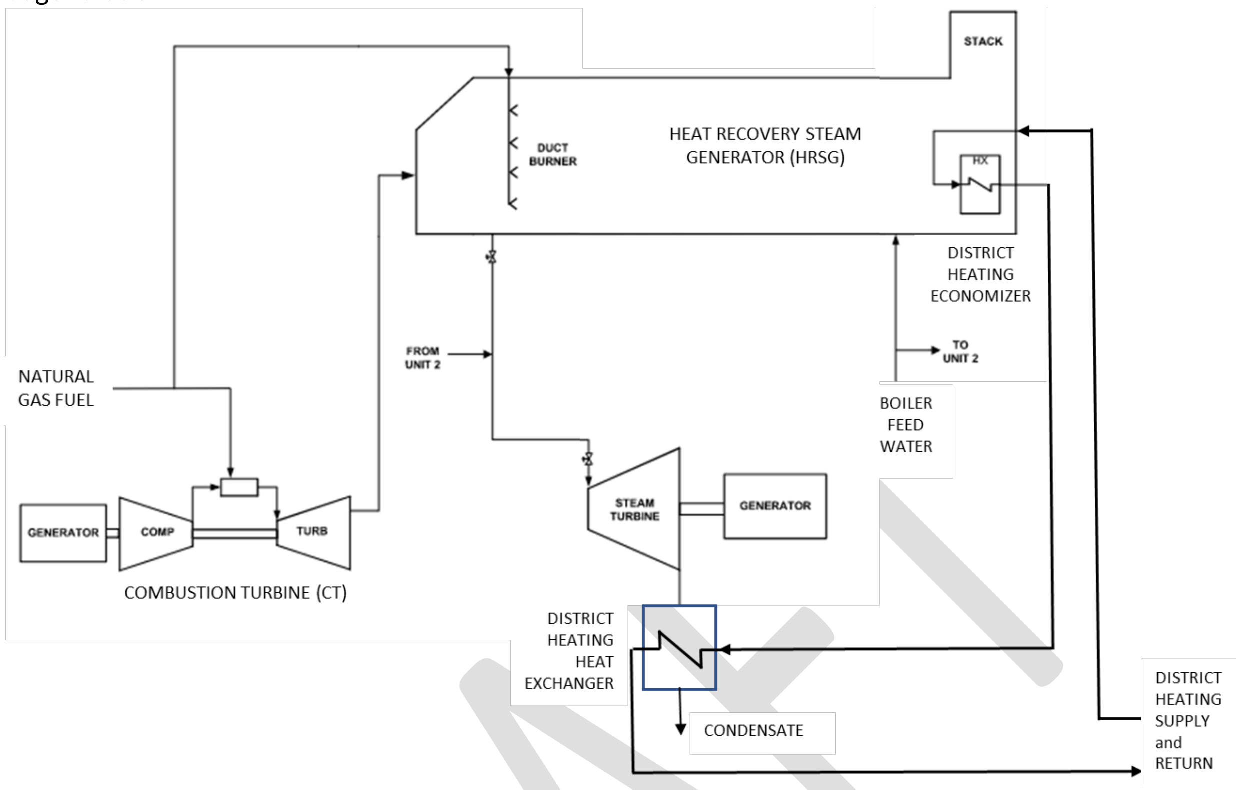


Figure 4-4 Cogeneration Process Flow Diagram

Low-pressure steam is exhausted from the steam turbine passes to the District Heating Heat Exchanger where the District Heating Hot Water is heated by the condensing of the steam. No cooling tower is used to condense the exhaust steam. This is where half of the heat produced by the combustion turbines, captured by the HRSG, and used to generate more electrical power in the steam turbine, is fully utilized. This final process is what makes a combined cycle cogeneration system efficient in a superior sense. Not having evaporative cooling towers saves energy and water, as mentioned above. Water can also be lost through the hot water district energy piping system. Since the Plan also includes upgrades to the piping system, repairs to leaks will reduce water losses and water demand by the TSEAD system.

Figure 4-5 shows the floor plan arrangement of each cogeneration building and its major equipment. The arrangement shown applies to both sites.

Cogeneration

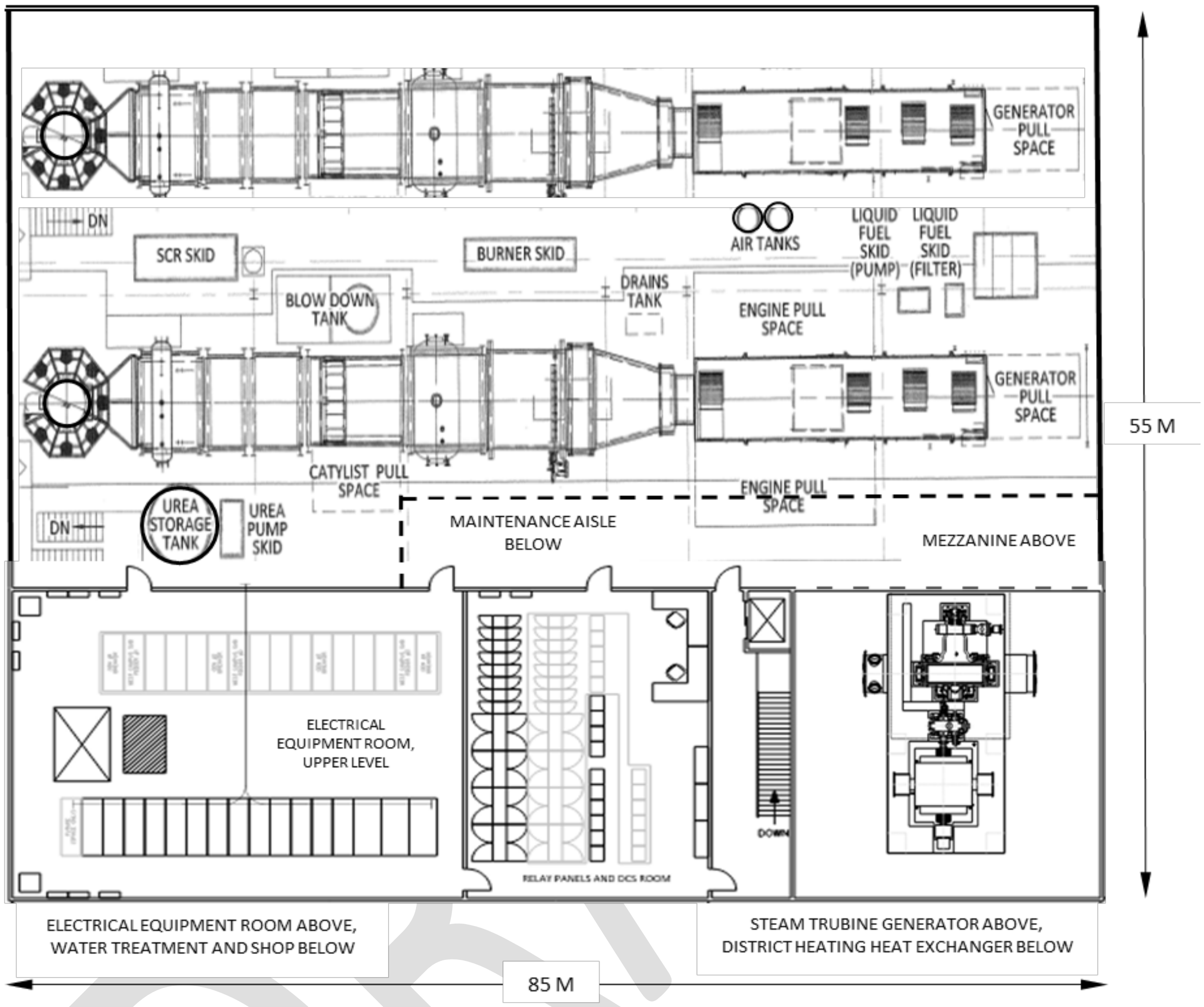


Figure 4-5 Cogeneration Plant Floor Plan Arrangement

The layout of the plant includes a single high bay area for the combustion turbines, HRSGs, and their balance of plant systems. The plant also includes a two story section for water treatment, district heating heat exchanger, pumps, and spare parts and shop areas at the ground level, and electrical rooms, control room, and steam turbine generator on a mezzanine level. The building would be approximately 85 meters by 55 meters and would require real estate around it for truck deliveries, lay down area, outdoor equipment such as natural gas metering and ammonia or urea storage, and car parking. There is space next to the Sofia East site to the east across the street, and there is space next to the Lyulin plant on its northeast side.

The capacity of the cogeneration plants will be selected to serve the summer and most of the spring and fall thermal loads. However, boilers are required to supplement the cogeneration systems thermal output in winter months. The boilers are located on several sites in Sofia. See section 3.4 for discussion on boilers, their capacities, and their locations.

Noteworthy are two boilers, EK-1 and EK-2 located at Sofia East. These are being replaced. The steaming capacity of each is 157 MWt. These boilers are serving new steam turbine generators, one for each boiler and each rated for 41 MWe. When the thermal load exceeds the thermal capacity of the cogeneration plants, Boilers EK-1 and EK-2 will be dispatched first, ahead of all other boilers, to cover the shortfall. As these boilers are engaged, their high pressure steam will first power the steam turbine generators to produce electricity as steam is produced to serve the thermal loads. Therefore, these first-on last-off boilers will operate to produce both heat and electricity, increasing total electrical power output by TSEAD.

Black & Veatch notes that for Sofia East the natural gas supply capacity is 240,000 nm3/h and the natural gas supply capacity at Lyulin is 120,000 nm3/h. Black & Veatch has estimated that the demand from the cogeneration plants and the boilers at these locations will not exceed the supply capacity.

In summary, the plan covers heat and electricity produced by the RDF plant at Sofia Central, heat and electricity produced by the two new cogeneration plants at Sofia East and at Lyulin, heat and electricity produced by boilers EK-1 and EK-2 and their steam turbine generators at Sofia East, and heat produced by other boilers at various sites. Table 4-3 summarizes energy loads and production from all the sources as projected in the year 2025.

Table 4-3 TSEAD System Outputs and Performance

Month			2025 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2025 Total
Days			31	28	31	30	31	30	31	31	30	31	30	31	365
Hours			744	672	744	720	744	720	744	744	720	744	720	744	8760
TECHNICAL INDICATORS															
I.	**ELECTRICITY**		**2025 Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**2025 Total**
1	**RDF gross production**	MWh	14,508	13,104	14,508	14,040	14,508	14,040	14,508	7,956	14,040	14,508	14,040	14,508	164,268
2	**Existing Plant STG gross**	MWh	59,740	53,959	59,740	0	0	0	0	0	0	0	4,947	59,740	238,127
3	**New Co-Gen gross**	MWh	374,824	338,249	371,719	241,951	154,002	143,119	134,073	143,042	145,315	176,714	359,871	374,720	2,957,599
4	**Electricity-gross production**	MWh	449,073	405,312	445,968	255,991	168,510	157,159	148,581	150,998	159,355	191,222	378,858	448,968	3,359,994
5	**Electricity-net production**	MWh	437,176	394,541	434,027	249,077	163,912	152,830	144,463	146,812	154,991	186,046	368,717	437,054	3,269,645
6	**Own needs - Total**	MWh	11,896	10,771	11,941	6,914	4,598	4,329	4,118	4,187	4,363	5,177	10,141	11,914	90,349
		%	2.65%	2.66%	2.68%	2.70%	2.73%	2.75%	2.77%	2.77%	2.74%	2.71%	2.68%	2.65%	2.69%
7	**Transformation losses**	MWh	6,864	7,102	6,597	4,209	2,787	3,378	2,976	3,876	3,906	4,484	7,337	7,343	60,857
		%	1.57%	1.80%	1.52%	1.69%	1.70%	2.21%	2.06%	2.64%	2.52%	2.41%	1.99%	1.68%	1.86%
8	**El. Energy for realisation**	MWh	430,313	387,440	427,430	244,867	161,125	149,452	141,487	142,936	151,086	181,562	361,379	429,712	3,208,788
II.	**HEAT**														
1	**Heat production**	MWh	759,608	664,958	615,906	259,842	185,084	173,688	166,880	150,825	170,983	203,237	514,685	796,214	4,661,909
1.1.	for Heat supply	MWh	745,935	652,988	604,204	255,164	182,493	171,603	164,877	149,618	168,589	199,985	506,450	785,067	4,586,975
1.2.	Own needs	MWh	13,673	11,969	11,702	4,677	2,591	2,084	2,003	1,207	2,394	3,252	8,235	11,147	74,934
		%	1.8%	1.8%	1.9%	1.8%	1.4%	1.2%	1.2%	0.8%	1.4%	1.6%	1.6%	1.4%	1.6%
2	**Heat supply**	MWh	745,935	652,988	604,204	255,164	182,493	171,603	164,877	149,618	168,589	199,985	506,450	785,067	4,586,975
3	**Heat losses**	MWh	84,291	84,888	77,942	61,239	61,683	62,292	63,972	59,099	63,389	68,995	95,213	87,927	870,932
		%	11.3%	13.0%	12.9%	24.0%	33.8%	36.3%	38.8%	39.5%	37.6%	34.5%	18.8%	11.2%	19.0%
4	**Heat for realization**	MWh	661,644	568,100	526,262	193,925	120,811	109,311	100,905	90,519	105,200	130,990	411,237	697,139	3,716,043
III.	**Natural Gas consumption**														
1	**Natural Gas**	MWh	1,379,012	1,218,675	1,200,785	550,393	352,871	327,215	306,319	321,093	327,125	402,602	1,002,509	1,420,955	8,809,553
1.1.	for CHP	MWh	845,160	763,063	838,921	545,800	346,911	321,775	300,984	321,093	327,125	398,535	812,180	845,166	6,666,713
1.2.	for Boilers	MWh	533,852	455,611	361,864	4,593	5,961	5,440	5,336	0	0	4,066	190,328	575,789	2,142,840
IV.	**CO2 emissions emitted from production**														
1	**Natural Gas**	t CO2	247,065	218,290	214,820	97,970	62,821	58,254	54,535	57,148	58,221	71,666	179,004	254,659	1,574,454
1.1.	from CHP	t CO2	150,412	135,802	149,305	97,139	61,742	57,269	53,569	57,148	58,221	70,929	144,546	150,414	1,186,497
1.2.	from Boilers	t CO2	96,653	82,488	65,515	832	1,079	985	966	0	0	736	34,459	104,246	387,957
VI.	**Co-Generation and Boiler Steam Turbine Plant Efficiency**														
1	Net Co-gen electrical efficiency	%	47.84%	47.81%	47.78%	47.79%	47.84%	47.92%	47.99%	47.99%	47.87%	47.80%	47.78%	47.82%	49.04%
2	Net System heat efficiency	%	60.54%	59.92%	56.01%	43.48%	43.71%	43.84%	43.88%	43.88%	43.77%	43.55%	52.36%	61.66%	52.92%
3	**Overall efficiency for the plant**	%	90.35%	90.55%	90.94%	91.27%	91.56%	91.76%	91.87%	91.87%	91.64%	91.35%	90.92%	90.46%	90.03%

High reliability is also a feature of the cogeneration and boiler system for TSEAD. In support of the new loop heat distribution system, having the cogeneration system supplemented with boilers located on various other sites contributes to reliability. If any one piece of heat producing equipment falters or even if an entire site falters, other equipment will cover. If thermal loads are at a maximum when a new unit of heat producing equipment falters, some of the existing boilers will remain on standby to cover any shortfall. The cogeneration system being a 2 x 1 configuration has reliability features built into its design. If a combustion turbine or HRSG falters, the other combustion turbine would remain online, producing its full capacity of electric power and delivering all its heat to its HRSG to deliver its steam to the steam turbine generator. Therefore, power and thermal production could be maintained at not less than half of the overall cogeneration plant capacity. If a steam turbine falters, the two combustion turbines would continue operating at up to their full output, and the steam produced in the HRSGs would bypass the steam turbine through a desuperheating pressure reducing station therefore delivering full plant capacity of heat to the district heating system with overall cogeneration power production reduced only by one third. There would be no need to take the entire cogeneration plant down for maintenance. Each turbine generator with its HRSG, and the steam turbine generator could be taken off line individually for maintenance as scheduled and as needed. Overall, the two cogeneration plants and the supplementary boilers will provide a very reliable district heating and electrical power production system.

4.4 New Boilers and NO_x Emission Reduction Upgrades to Existing Boilers

As discussed earlier the majority of the equipment including the hot water boilers are towards the end of their useful life and cannot achieve the required NO_x limits even when operating at part loads. The average monthly heat load, even during the peak demand month of December, is significantly less than the occasional peak demand, which in turn is significantly lower than the installed capacity at the Sofia district heating plants. Black & Veatch is of the opinion that new boilers of their total capacity that can serve up to the nominal peak load should be considered.

4.4.1 Two New Steam Generators at Sofia East

Two of the steam turbines in Sofia East are new. One of the steam turbines produced by Siemens was installed in 2019 and another steam turbine is being installed and expected to start service at the end of 2021. However, the four 220 t/h steam generators providing steam to these steam turbines were installed in 1960s and are at the end of their useful life. Therefore, Black & Veatch recommends replacement of two of the existing steam generators with new steam generators of like capacity.

4.4.2 New Hot Water Boilers

Since the majority of the hot water boilers are near the end of their useful life, Black & Veatch recommends adding four new hot water boilers to provide hot water during winter months when the thermal demand is high. Based on the preliminary study conducted by TSEAD it was determined that the new boilers should be located at Sofia East, Sofia Central, Zemlyane, Ocha Kupel 1 and Ocha Kupel 2.

4.4.3 NOx Emission Controls on the Relatively New Boilers

While the majority of the hot water boilers are near their end of typical useful life, there are a few boilers that appear to be relatively newer having less than 25 years in service and can continue operating in the future provided appropriate NOx emission controls are installed on them. These include two boilers at Sofia Central, 2 boilers at Zemylane, and one boiler at Lyulin.

Since cogeneration plants provide both thermal and electrical energy, the cogeneration plants will be dispatched first to meet the heat load. When the cogeneration boilers are operating at their maximum, the new boilers designed for low emissions and higher efficiency will be dispatched next. Therefore, the older boilers will likely be called in service for very limited number of hours each year. Therefore Black & Veatch considers that these boilers can continue to operate for the next 25 years with appropriate maintenance.

NO_x emission control recommended for these boilers include low NO_x burners, overfire air, flue gas recirculation and selective noncatalytic converters. One or more of these emission controls can be used to achieve EU NO_x compliance limit of 100 mg/Nm^3. Black & Veatch recommends conducting detailed study on these boilers to determine the appropriate NO_x emission controls.

Table 4-4 provides the summary of all the new and existing steam and hot water boilers and indicates if they are intended for primary use, or intended for backup use or intended to be retired in place.
Table 4-5 provides the total primary capacity, total back up capacity and the total available capacity

Table 4-4 TSEAD Boiler Age, Condition, and Disposition

Boiler Number	Year of Commission / New	Capacity (MW)	Primary / Backup / Retire	NOx Emission Upgrades
SOFIA CENTRAL				
EK6	1957		Retire	NA
EK 7	Decommissioned			
EK 8	1964		Retire	NA
EK9	1985		Backup	None
BBK1	1967		Retire	NA
BBK2	1967		Retire	NA
BBK3	1973		Backup	None
BBK4	1998		Primary	NOx upgrades Recommended
BBK5	1983		Backup	None
BBK6	1995		Primary	NOx upgrades Recommended
New Boiler	NA	100	Primary	NA
SOFIA EAST				
EK1	1964	157	Retire	
EK2	1964	157	Retire	
EK3	1967	157	Retire	
EK4	1968	157	Retire	
EK5	1988	152	Backup	None
EK6	1988	152	Backup	None
EK7	1988	152	Backup	None
New Steam Generator 1	NA	157	Primary	NA

Boiler Number	Year of Commission / New	Capacity (MW)	Primary / Backup / Retire	NOx Emission Upgrades
New Steam Generator 2	NA	157	Primary	NA
BK1	1974	116	Retire	None
BK2	1974	116	Backup	None
BK3	1975	116	Backup	None
BK4	1975	116	Backup	None
BK5	1977	116	Backup	None
BK6	1981	116	Backup	None
BK7	1982	116	Backup	None
BK8	1982	116	Backup	None
New Hot Water Boiler 1		125	Primary	
ZEMELYANE				
BK1	1999	116	Primary	NOx upgrades Recommended
BK2	2000	116	Primary	NOx upgrades Recommended
BK3	1976	116	Retire	NA
BK4	1976	116	Backup	None
BK5	1982	116	Backup	None
New Boiler		100		
LYULIN				
BK1	1977	116	Backup	None
BK2	1977	116	Backup	None
BK3	1998	116	Primary	NOx upgrades Recommended
BK4	1979	116	Backup	None
BK5	1989	116	Backup	None
OVCHA KUPEL 1	1990	43.6 (Six 8.7 MW Boilers)	Backup	None
OVCHA KUPEL 2	1988	43.6 (Six 8.7 MW Boilers)	Backup	None
New Boilers at OVCHA KUPEL 1 and 2		43.6 (Six 8.7 MW Boilers)	Primary	NA
Suha Reka	1976	35	Retire / TBD	None
H. DIMITAR	1983	46.8	Retire / TBD	None
LEVSKI G	1991	43.6	Retire / TBD	None
ORLANDOVTSI	1985	5	Retire / TBD	None
INJSTROY	1980	19.7	Retire / TBD	None

4.5 GHG Discussion and Plan Conclusions

4.5.1 GHG Discussion

A major imperative for TSEAD is achieving sustained GHG reductions. A number of steps have been considered to support the company's efforts.

- *Renewable Generation*: Since renewable energy generation, such as solar photovoltaic (PV) and wind, is an approach to reduce GHG with certainty, Black & Veatch had requested Sofia municipality to seek any large plots of land currently owned by the Municipality suitable to accommodate PV generation. To date, no suitable land that would facilitate a large scale PV project has been identified, but the search will continue. However, small scale PV projects, ground and roof mount, can be considered during detail design. Sofia is not deemed an area suitable for wind power generation.
- *Hydrogen Compatibility*: There is a worldwide effort underway to make commercially feasible as a fuel source. Importantly, the gas turbines planned to provide the electrical and thermal load considered in this Plan can support 32 percent to 50 percent hydrogen by volume in the fuel. At these levels, significant GHG reduction can occur as soon as hydrogen becomes available without turbine replacement.
- *Efficiency*: Although, improvements in efficiency do not eliminate the production of GHG emissions, significant reductions of GHG emissions can be achieved. Considering the lack of readiness and the high cost of hydrogen at this time, comparing the cogenerated power produced in the Plan with a typical Rankine Cycle plant is instructive and noteworthy. Compared to the 2018 performance projections, the Plan produces 2,868,000 MWh of additional net electrical generation, whereas the fuel usage beyond what would have been used to generate hot water to serve the thermal loads is 3,599,000 MWh. This results in an effective electrical efficiency of approximately 80 percent. This is significantly higher than any conventional generation technology that currently exists including the most advanced class combined cycle power plants, and more than twice the typical electrical efficiency of 35 percentage for a Rankine Cycle plant. This means a reduction of fuel to 43.8 percent of Rankine Cycle fuel. If the Rankine Cycle plant is using coal as its fuel, the natural gas fueled cogeneration plant in the Plan provides an even greater reduction in emissions. According to the US Energy Information Administration, natural gas produces 181 kg CO_2/MW fuel burned, and coal produces 325 kg CO_2/MW fuel burned, meaning burning natural gas emits 44.3 percent of coal emissions on a MW fuel basis. Considering that the cogeneration plant uses 43.8 percent of Rankine Cycle fuel on MW production basis, and natural gas emits 44.3 percent of coal emissions on MW fuel basis, then the natural gas cogeneration plant would emit only 20% of Rankine Cycle coal GHG emissions on MW production basis. Therefore the Plan offers a significant reduction of national CO_2 emissions.

4.5.2 Plan Conclusions

- By investing in new equipment and in the distribution system, the Plan will provide adequate redundancy for hot water through year 2050, thereby substantially increasing the heat reliability for TSEAD customers. It should also be noted that system reliability will be substantially enhanced by vendor support for major new components, to include warranties, training and technical support, and ready availability of spare parts. All of these important elements are of course lacking for the existing equipment.

- The Plan will improve thermal and electrical efficiencies and will significantly reduce the GHG for Bulgaria by replacing coal fired generation.
- The Plan will ensure that NOx emissions are below the Industrial Emissions Directive 2010/75/EU.
- The Plan will significantly reduce the safety risk for TSEAD workers by having newer equipment, not using the old equipment, and investing in critical safety upgrades to all the heating plants.
- The Plan will significantly reduce CO_2 emissions.

5.0 Financial

5.1 Assessment of TSEAD's Current Financial Condition

The main activities of TSEAD are the production, transmission and sale of heating energy and production and sale of electricity. In support of its main activities, the Company carries out large-scale repair activities in the heat sources and the heat transmission network.

The Company currently earns revenue through (i) the sale of heat at regulated tariffs (64%); (ii) the sale of electricity on the day-ahead Bulgarian Energy Exchange ("**IBEX**") (15%); (iii) a subsidy premium on the price of electricity paid from Bulgaria's Electricity System Security Fund ("**ESSF**") (12%); and (iv) other ancillary income, such as interest on late payments, (9%). It is important to note that the 4:1 ratio of heat to electricity production is well above average for district heating systems globally, which typically strive for nearly 1:1 output.

The prices of heating energy and electricity are subject to regulatory rules and are determined by the Energy and Water Regulatory Commission ("**EWRC**") in accordance with the requirements of Ordinance No. 1/18.03.2013 for regulation of electricity prices and Ordinance No. 5/23.01.2014 for regulation of heating energy prices. By law they are to be based on estimated costs for the activities under the licenses held by the Company and a return on capital set by EWRC.

Historically there has been a significant deviation between the pricing costs approved by EWRC and the actual costs that the Company incurs to conduct its licensed activities. In addition, several significant costs, including penalties on current liabilities for natural gas, interest on agreements with Bulgaria Energy Holdings ("**BEH**"), the costs of impairment of receivables, the contribution to the Electricity System Security Fund, are not recognized under Ordinance No.1 and Ordinance No.5 on price formation of electricity and heat. Further, during recent regulatory reviews, the EWRC has not fully recognized, or delayed recognizing costs related to the regulated activity (depreciation, allowances, salaries and insurance, repairs, etc.).

As a result of such regulatory factors and the structural imbalance in heat and electricity output, the Company has been operating at a loss for the past eight years. To date, the Company's operating losses have been funded through increased borrowings from BEH and Bulgargaz EAD ("**Bulgargaz**"), thus resulting in ever increasing debt service requirements. Whilst important actions implemented by management in 2020 (e.g., renegotiation of the terms proposed by Bulgargaz under the natural gas supply contract for 2021) have been aimed at improving the overall financial situation, the Company remains locked in a long-standing debt spiral. Unless chronic and fundamental problems with the Company's ageing equipment and distribution infrastructure, underfunded maintenance, inadequate electricity generation and large and growing accrued debts are fully addressed, it is certain that the situation will continue to deteriorate.

In 2019 and 2020, TSEAD recorded a loss in the amount of BGN 82.5M and BGN 67.2M respectively. In 2019, the Company recorded negative EBITDA and EBIT of BGN 54.3M and BGN 82.4M. Similarly in 2020, it recorded negative EBITDA and EBIT of BGN 36.6M and BGN 68.8M.

Table 5-1 TSEAD Financial Results 2019-2020

BGN Millions:	December 31, 2020	December 31, 2019
Net Income	-67.2M	-82.5M
EBITDA	-36.6M	-54.3M
EBIT	-68.8M	-82.4M

Since 2012, the Company has accumulated losses of BGN 397.0M. This has resulted in the gradual decrease of Shareholder's equity and worsening financial situation for the Company.

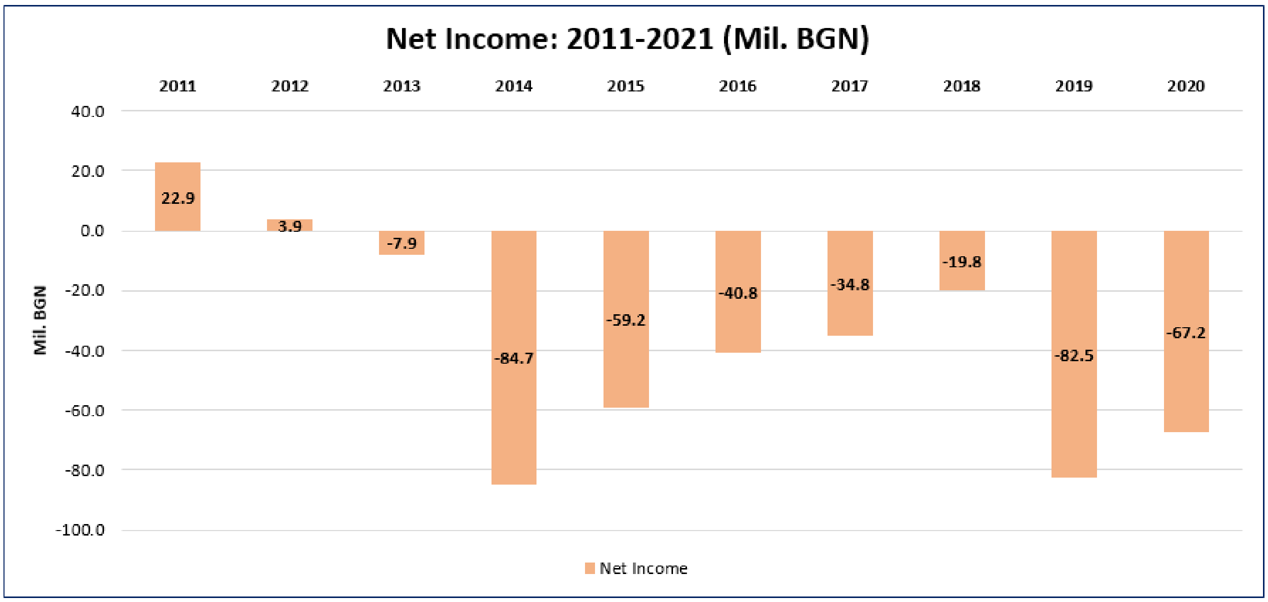
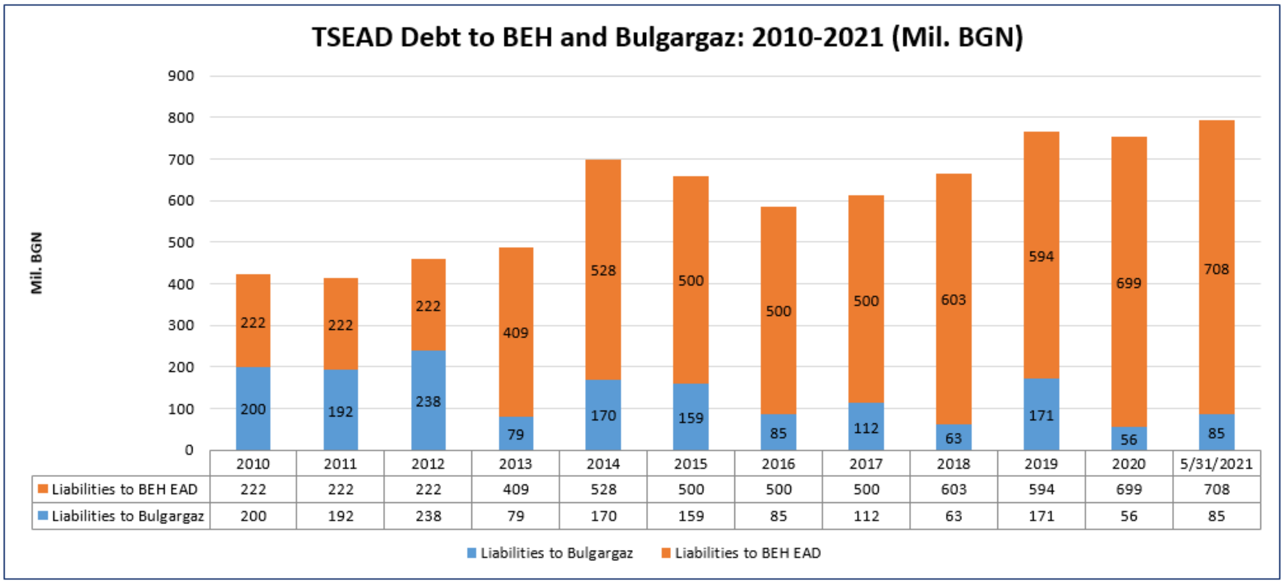


Figure 5-1 TSEAD Net Income 2011-2020

As discussed earlier, the persistent losses have required the Company to borrow from external entities to fund its operations. As can be seen below, the gradual accumulation of losses of BGN 397M is mirrored by a similar increase in the total debt that the Company accumulated from BEH and Bulgargaz.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	5/31/2021
Liabilities to BEH EAD	222	222	222	409	528	500	500	500	603	594	699	708
Liabilities to Bulgargaz	200	192	238	79	170	159	85	112	63	171	56	85

Figure 4-2 TSEAD Debt to BEH and Bulgargaz: 2010-2021 (Mil. BGN)

In addition, from a review of the latest TSEAD annual report, certain financial indicators for TSEAD are discussed below.

Liquidity Ratios

- **Total Liquidity Ratio:** December 2020: 1.13 vs December 2019: 1.01
- **Quick Liquidity Ratio:** December 2020: 1.01 vs December 2019: 0.89

One determinant of a company's debt capacity is the liquidity of its assets. An asset is liquid if it can be readily converted to cash, while a liability is liquid if it must be repaid in the near future. The total liquidity ratio compares the assets that will turn into cash within the year to the liabilities that must be repaid within the year. TSEAD's liquidity ratio near one means that TSEAD does not have liquidity and it is not able to turn its current assets in cash to meet maturing obligations. Therefore, TSEAD will have to rely on operating income and outside financing—in this case becoming indebted to Bulgargaz and BEH. The quick liquidity ratio is similar to the total liquidity ratio, except that it ignores inventory—which is usually illiquid.

In 2020, mostly to alleviate short-term liquidity issues, the Company entered into a working capital facility with Bulgarian Development Bank AD with the following terms:

- **Amount:** BGN 40M (drawn on December 31, 2020 BGN 36.3M)
- **Term:** 36 months from the date of conclusion July 2020 to July 2023
- **Interest:** 3 - month EURIBOR + 3.0% surcharge (with 3.0% minimum)
- **Use of Proceeds:** to cover cash flow shortage due to refund/set-off of amounts on customers' balancing accounts, due to regulatory changes
- **Management Fee:** 0.1% per year
- **Commitment Fee:** 0.25% per year
- **To be utilized by:** December 31, 2020

Financial Leverage

- **Debt-to-Equity:** December 2020: 4.94 vs December 2019: 3.60
- **Debt-to-Assets:** December 2020: 83% vs December 2019: 78%

The debt-to-equity ratio indicates TSEAD dependence on external sources of financing—the higher this ratio, the more TSEAD needs to rely on external financing. The increase in the debt-to-equity ratio in 2020 was due to the decrease in the amount of equity because of the reported loses in 2020. Furthermore, the debt-to-assets ratio indicates that 83% of the assets of the Company are financed with debt. The increase in debt-to-asset in 2020 is related to the reduced value of assets such as trade and other receivables.

Profitability Indicators

- **Return on Equity (ROE):** December 2020: -0.33 vs December 2019: -0.30
- **Return on Assets (ROA):** December 2020: -0.06 vs December 2019: -0.07
- **Return on Fixed Capital:** December 2020: -0.62 vs December 2019: -0.77

ROE measures the efficiency with which the Company is employ's equity capital—it is the Company NI divided by the amount Shareholder's equity. Since TSEAD is generating loses the ROE is negative. The Company has three levers of managing ROE: profit margin, asset turnover and financial leverage.

ROA measure the efficiency with which the Company allocates and manages its resources—it is the Company NI divided by Total Assets. In other words, it measures profit as a percentage of money provided by the owners and creditors as opposed to only owners. In the case of TSEAD, it is negative because of the losses the Company is generating.

5.2 Main Causes of TSEAD Financial Condition

5.2.1 Price Setting Mechanism for Heat and Electricity Tariff

EWRC is the specialized independent state institution in charge of regulating the activities in the Bulgarian energy and water supply and sewerage sectors. Under current regulation, EWRC sets TSEAD's heat tariff and the preferential electricity price via a rate of return on capital ("**Cost-plus**") price regulation.

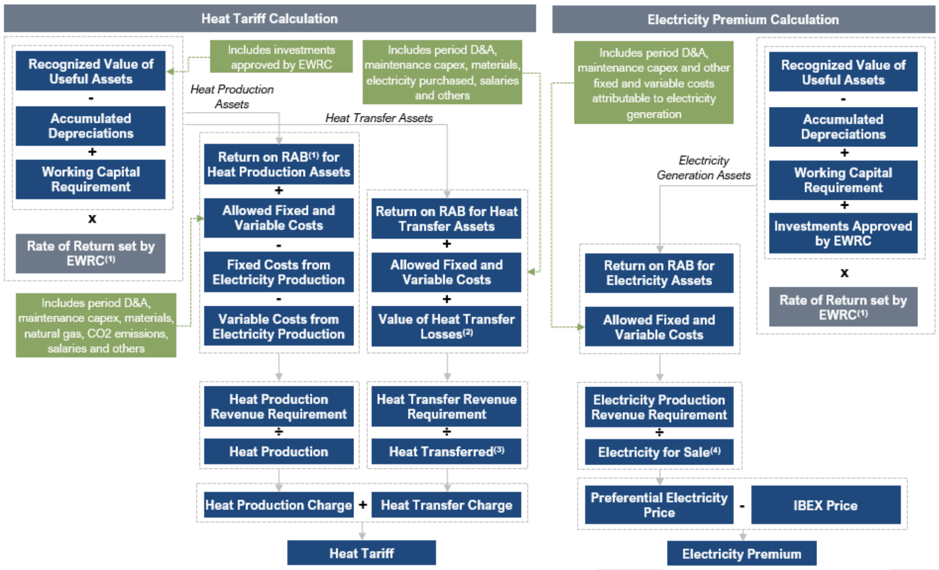


Figure 5-3 Heat and Electricity Tariff Calculations

EWRC approves prices and monitors on an ongoing basis the actual values of the revenue requirements of regulated energy companies and their components. EWRC key tasks include the following:

- Analysis of reported and forecast information provided by energy companies.
- Approval of estimated revenue requirements for energy companies, including economically justifiable costs of licensed activities and rate of return on capital.
- Approval of prices based on forecast quantities.
- Setting the duration of the regulatory period and the values of the factors, on the basis of which the prices are changed during the regulatory period

Under the current regulatory regime, the EWRC regulatory review period runs annually, commencing on July 1st each year, and are intended to remain fixed unless substantial deviations between approved and actual costs/ returns arise within the year. Further, TSEAD is required to submit its applications for approval by EWRC no later than 4 months prior to the expiration of each rate period, with significant risk that necessary adjustments occurring after submission but before the effective date may not be fully recognized at the start of each regulatory period.

Given the fact that the process of prices forming for the main revenues and expenses of the Company is subject to regulatory rules as applied by EWRC, the possibility of corporate governance to influence price risk is very limited. As discussed earlier, to date there has been a significant deviation between the pricing costs approved by EWRC and the actual costs that the Company has incurred to conduct its licensed activities. In addition, several important costs cannot be considered in the formula calculation, including penalties on current liabilities for natural gas, interest on agreements with BEH, the costs of impairment of receivables, the contribution to the Electricity System Security Fund. Further, to date EWRC has not fully recognized, or has delayed in recognizing certain other costs related to the regulated activity (depreciation, allowances, salaries and insurance, repairs, etc.). The combination of these factors creates significant pressure on the ability of TSEAD to operate profitably.

Another key component of the regulatory regime that is used for determining heat and electricity tariffs, is the rate of return. The rate of return is applied to the regulated asset base in determining the allowed return on the assets of TSEAD. It is included by law in the calculation of yearly heating and electricity prices. As can be seen below, the target rate of return set by EWRC for TSEAD has varied over the last decade years within the 4-7% range. Following a period of growth in the 2016-18 period, rates have remained flat at 7% and then dropped to 5% in 2020. The rate of return for the 2021-22 regulatory period decreased further to 4%.

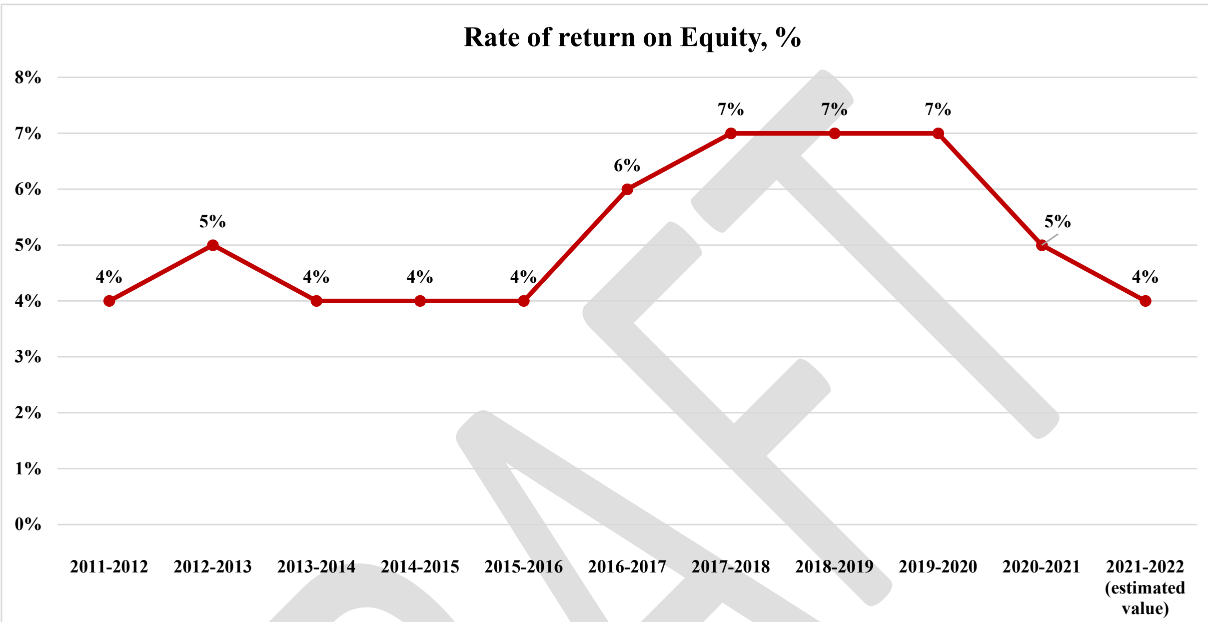


Figure 5-4 Return on Equity (%)

Based upon historical experience, management does not expect future heat tariffs to deviate materially from historical levels given EWRC's desire to ensure a generally acceptable cost of heat for the residents of Sofia.

5.2.2 Natural Gas Supply Contract with Bulgargaz

Currently 100 percent of TSEAD's gas is supplied by PJSC Gazprom ("**Gazprom**") through Bulgargaz under a short-term gas supply agreement. Whilst the contract is renewed on a yearly basis as to volume, the contract price for delivery of natural gas is set on monthly basis. In contrast, heat and electricity tariffs are set on a yearly basis, with the result that gas price changes within the year are not timely or fully recognized in the regulated tariffs.

Accordingly, although the formula set by the EWRC should provide for the full recovery of variable costs such as natural gas price, which in 2020 and 2019 accounted for 42.3% and 56.7% of overall operating expenses, close inspection of natural gas prices and heating and electricity tariffs for the period 2012-2021 presents a different picture. For example, the price of natural gas increased by 136% between July 2020 and June 2021 (going from 201.73 BGN/knm3 to 476.15 BGN/knm3) whilst heating tariff remained at 82.09 BGN/MWh and the electricity rate remained at 168.73 BGN/MWh during the same period.

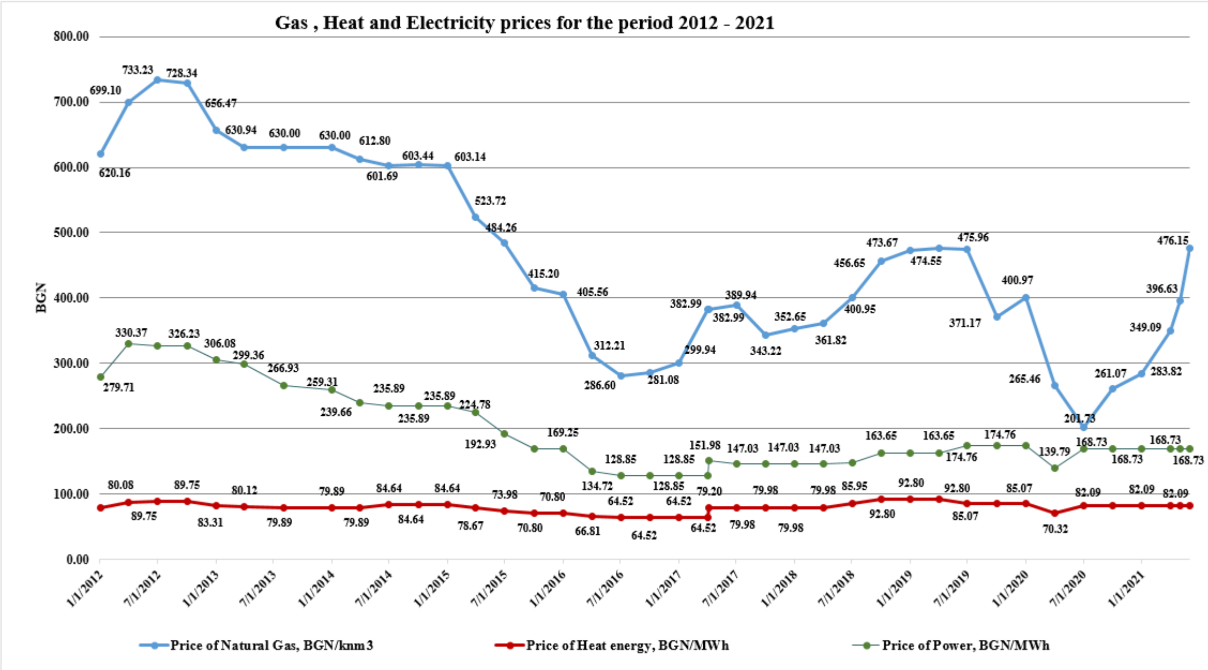


Figure 5-5 Gas, Heat and Electricity Prices for the Period 2012-2021

In addition, under the recent and current gas supply contracts, TSEAD incurs penalties payable to Bulgargaz in circumstances where it is unable to buy the scheduled daily agreed quantities outside a +/- 5% deviance range. Penalties payable amount to 10% of the price for quantities outside this range. And further, the contract payment terms impose a 10% penalty on each invoice from the date of issuance to the date of payment, while TSEAD's collections for the energy generated from the supplied gas are billed and collected 45 days later on average, creating a significant structured loss. These penalties and interest on debt to BEH amounted to BGN 16.3M in 2020, comprising 24.3% of TSEAD reported loss for the year.

Table 5-2 Penalties and Interest Resulting from Gas Contract

Penalties and Interest Resulting from Gas Contract	2016	2017	2018	2019	2020
Net Income (BGN in Million)	-40.8	-34.8	-19.8	-82.5	-67.2
Penalties to Bulgargaz (BGN in Million)	7.8	7.8	12.0	10.8	2.3
Interest to BEH (BGN in Million)	16.0	19.5	19.0	20.9	14.0
Penalties and Interest as percentage of NI losses	58.3%	78.4%	156.7%	38.4%	24.3%

Again, penalties and interest accrued on any outstanding unpaid liability are not included for recovery within the current regulatory pricing mechanism.

5.2.3 Increasing Liabilities Toward BEH and Bulgargaz

As discussed earlier, TSEAD's recurring losses have required the Company to borrow from BEH and Bulgargaz to fund its operations. In effect BEH and Bulgargaz are *de facto* subsidizing TSEAD operations by providing loans to keep the Company solvent.

Non-current and current liabilities of the Company as of December 31, 2020 amounted to BGN 1,003.5M. As at the end of 2020, the BEH and Bulgargaz liabilities accounted for more than 75% of TSEAD total liabilities.

Table 5-3 Liabilities for 2020

Liabilities for 2020	BGN Millions	Relative Share (%)
Natural Gas	754.7	75.2%
- to the BEH	*699.1*	*69.7%*
- to Bulgargaz EAD	*55.7*	*5.5%*
Carbon Emissions Liabilities	56.1	5.6%
Other Suppliers	18.5	1.8%
Bank Credits	36.3	3.6%
Pension and Other Payables to Staff	14.8	1.5%
Tax Liabilities	3.4	0.3%
Liabilities Under Deferred Taxes	66.5	6.6%
Grants Awarded	53.2	5.3%
Total Liabilities	**1,003.5**	**100.0%**

As the amount of liabilities to BEH and Bulgargaz has continued to increase over the years, so has the amount of interest paid by TSEAD to service those liabilities. Coupled with the fact that under the current regulatory regime EWRC does not allow the inclusion of interest on the obligations to BEH and Bulgargaz, this has contributed to a continuously deteriorating financial situation for TSEAD. This situation will continue to deteriorate unless immediate actions are taken.

5.2.4 Inability to Collect on Past Due Bills, and Going Through Legal Process to Collect Payments

The Company has tried to implement effective management of receivables and to increase collections by optimizing and improving internal processes related to collections. However, various economic, social and political factors still influence debt collection activities. This dynamic environment requires the application of flexible and adaptive approaches in the process of communication with irregular customers and analysis of results. An additional challenge to the collection is the fact that the heating energy bills have a relatively low priority in the payment of debts by the population due to the lack of restrictions related to the termination of the service.[5] Moreover, Covid-19 pandemic has affected debt collection activity by limiting personal contacts with customers and attempts to negotiate payments in person.

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[5] TSEAD 2020 Annual Report.

Furthermore, the Company is forced take customers to court in order to collect on past-due accounts. In the twelve-month period ending December 31, 2020, TSEAD filed a total of 8,715 cases against customers in the relevant court. Concurrently, customers filed 454 cases against the Company. Finally, TSEAD has filed a total of 9,761 enforcement cases with the courts during the twelve-month period ending December 31, 2020.

Legal and enforcement actions affect both the Company's ability for timely collection and financial performance.

5.3 Financial Objectives for Restructuring

As part of the upgrade, remediation, and recapitalization plan currently being considered, it is expected that TSEAD will be restructured into a financially viable, stable, self-sustaining and profitable company. The transformation of TSEAD into a financially viable company is clearly vital for the social and common good of the city of Sofia and Bulgaria.

As described in this Task 2 Report, the key elements of the plan include a significant increase in electricity output to grow revenues, and an upgrade and expansion of the thermal distribution system to dramatically improve service. This program will require capital expenses estimated at c.€860,000,000. In order to ensure competitively priced financing is obtained for this program, two key actions should be considered as priorities:

1. **Alternative Gas Supply:** Secure alternative gas supplies, ideally under a long-term agreement, for a portion of TSEAD needs, to reduce dependency on Bulgargaz. Marathon understands that the 3bcm p.a. (up to 5 bcm p.a.), c.180km Gas Interconnector Greece-Bulgaria and the newly financed Alexandrouplis LNG terminal in Greece (regasification capacity of 5.5bcm p.a.) are expected to become operational by 2022 and 2023 respectively. These projects will contribute materially to the diversification of gas sources in Bulgaria and are expected to result in significant improvement in gas prices.

2. **Power Purchase Agreement ("PPA"):** Execute one or more long-term, bankable, PPAs for all or a portion of the electrical production resulting from the upgrade. Such agreements are expected to refocus and enhance the counterparty risk from TSEAD to a highly rated electricity off-identified taker. As discussed later in this report, positive discussions with creditworthy entities that could enter into such contract have already been initiated.

Concurrently with this, it is intended that TSEAD will enter into discussions with BEH and Bulgargaz to renegotiate existing debt terms to ensure these are subordinated to the new debt and brought to mutually agreed and sustainable levels in the long-term.

5.4 Available Sources of Funding for TSEAD and Investment Structure Options

The objective of the financing workstream is to maximize the amount of external debt financing that can be made available to finance the Plan upgrades, whilst at the same time minimizing financial costs and ensuring enough cash is left to repay the BEH and Bulgargaz obligations.

Marathon Capital LLC ("Marathon") is Black & Veatch's financial advisors subcontractor. In preparing this Report Marathon has identified three categories of potential lenders, including: (i) international and domestic commercial banks, (ii) multilateral development banks ("**MDB**"), and (iii) Export Credit Agencies ("**ECA**"). Plan. In addition to traditional sources of debt financing presented below an important source of financing for the project may be made available in the form of grants from various sources. Each of these potential sources of funding is discussed below.

Group 1: International and Domestic Commercial Banks

Commercial lenders will most likely be part of any financial package arranged with participation from both international and domestic banks. The list developed by Marathon includes major lenders active in Bulgaria as well as leading lenders active at the European level with a significant presence in Eastern Europe.

Whilst initial introductory discussions have been held with a number of these institutions, Marathon believes that formal outreach to commercial lenders should be undertaken only once the financing structure and key stakeholders becomes better defined. As a result, our initial approach has favored more informed discussions amongst Groups 2 and 3 (see below).

Group 2: Export Credit Financing (with Vendor Collaboration)

Financing with the support of ECAs can be made available with the support of equipment vendor for the CHP plants and other related equipment (e.g., hot water boilers) that could be contracted with the vendor. The list currently being considered by Marathon includes ECAs from different countries including Germany, Sweden, Switzerland and US. It should be noted that ECA financing is usually arranged by the vendor who tends to work with the ECA of the country in which the equipment is manufactured. In the specific example of the GE and Siemens, the ECAs typically involved in providing financing are SERV (Switzerland) for GE and EKN (Sweden) for Siemens. Whilst specific vendors tend to work with the same ECAs over different transactions, potential to include multiple ECAs should not be excluded.

Initial conversations with ECAs (e.g., SERV) have indicated that terms for this type of financing will involve a certain portion of export credit value (generally up to 85%) with a portion of local costs also allowed (up to 50% of local costs contracted with the vendor) that ECAs are willing to guarantee. Marathon is currently refining its view with regards to the actual amount that could be available under the export contract in conversations with the vendors. Whilst GE have previously provided TSEAD with a proposal involving the supply of the turbines only, Siemens have provided TSEAD a proposal that accounts for the provision of the full EPC services for the CHP plants. Depending on actual terms received from future interactions with ECAs, it is possible that our strategy for financing the capex for the upgrade will try to ensure that a significant portion of the EPC cost for the CHP plants (including potentially the hot water boilers) will be wrapped under the export contract value to maximize the amount available under ECA financing.

ECAs will generally work with commercial lenders and charge an upfront flat fee depending on the rating of the corporate (in case of corporate level financing) and the overall security package. Based on initial conversations, we expect ECA financing will be available through the planned three year construction period and for an additional period of 12-14 years following completion depending on actual specifications of the financing package (i.e., corporate vs. project financing).

Unlike many multilaterals, ECAs currently have less strict limitations on the technology type they are able to finance (e.g., ability to finance certain gas generation projects). However, it is understood that thorough environmental due diligence will be performed as part of the review of any potential transaction.

Group 3: Multilateral Development Banks (MDBs)

MDBs are a very credible option for providing part of the financing required for the upgrade. Generally, MDBs tend to operate within strict parameters provided by their governments with regards to countries and types of projects they can invest in, as well as actual amounts that they can make available. However, they tend to have certain level of flexibility and their ability to participate in a specific project will depend on a multitude of factors (e.g., geopolitical, climate, economic, etc.).

It should be noted that increasingly there is a growing unwillingness among such MDBs to finance gas fueled power generation projects. Notably, the European Investment Bank announced earlier this year that it will no longer finance natural gas fired power plants. Governments' policies with regards to natural gas are still evolving and vary from country to country. As an example, new guidelines for US government backed lending agencies issued by the Treasury Department in August 2021 impose new restrictions on loans to all carbon-based power generation projects. However, the department has expressly made an exception for district heating projects, noting:

"We recognize that coal plays a significant role as a heating source in some regions and the substantial harm caused by dirty cooking fuels. We are open to supporting oil and gas projects as coal alternatives for household cooking and heating. We may also consider oil and gas projects for other heat generation purposes (e.g., industrial uses) where there are no other feasible alternatives."

Initial conversations with US MDBs indicated there is interest in participating in financing the TSEAD upgrade with the potential to lend up to $400m for the project. In order to ensure the highest likelihood of participation in the financing from any MDB, including those in the US, it will be key to ensure that the upgrade project continues to be presented as a project of significant importance that will be able to (i) achieve significantly better efficiencies with reduced overall emissions in light of its social mission, (ii) displace higher emission generation in the country, (iii) increase competition amongst potential gas suppliers within the region, and (iv) eventually allow for a significant portion of the fuel supply to include hydrogen.

Group 4: European and International Grants

An important source of low-cost financing for the project could be made available in the form of grants. Marathon is currently analyzing potential availability of such grants with the intent of maximizing any amount that could be made available. In general, allocations of EU grant funds is determined at the national government level. Accordingly, access to such grant funds for use in Plan implementation will require discussion between the Municipality and the Bulgarian Government. For purposes to developing a funding program for the Plan, no such funds are included at this time. Of course future access can only enhance the funding program.

5.5 Investment Structure Options

Marathon has prepared an initial information summary with an overview of the project and the Company and is in the process of reaching out to lenders to explore investment structure options. A discussed earlier, the objectives of the financing workstream are:

1. Maximize the amount of debt for the project
2. Safeguard that TSEAD remains owned by Sofia Municipality
3. Ensure that the investment would result in a financially sound and profitable company

5.5.1 Structuring Levers

The investment structure is driven by a multitude of factors. We see three primary levers:

- Structuring the debt as a corporate level financing vs. project level financing
- Securing sources of cash flow to service debt – heating and electricity revenue partially offset by operating expense predictability
- Considering partial recourse or other guarantee from by the Sofia Municipality

Structure. An initial consideration for the investment structure is whether the financing will be obtained at a corporate level or project level. Under a corporate level financing with recourse, a secondary source of repayment would include all the assets and activities of the Company. On the other hand, in the case of a project level financing, the Company would create a Special Purpose Vehicle ("**SPV**") that would be used to contract the sale of electricity and borrow against the revenue generated by the sale of electricity without any recourse on the Company's assets in case of default. Project level financing offers the distinctive feature of significantly minimizing risk to TSEAD since creditors rely exclusively on project revenues to service debt without recourse to other assets of the Company in case of default. Based on initial assessment of the situation, it is highly likely that the appropriate financing structure to finance the upgrade will be hybrid; that is it will include some portion of project level financing, together with a portion of corporate level financing with the potential of a limited parent guarantee as a credit enhancement feature.

Cash Flow Security. The main consideration in debt sizing to support implementation of the Plan is the amount and availability of reliable free cash flow to service such debt. TSEAD has two main sources of revenues: heating and electricity sales. Currently, heating revenue accounts for approximately 64% of the total, with just 15% coming from the sale of electricity (plus subsidy payments for another 12%). Implementation of the Plan will dramatically alter this ratio by producing substantially more electricity, thereby generating significant additional cash annually which can be used to service debt. Lenders will also consider the stability and predictability of the cash flows in debt sizing. In general, lenders have preference for contracted cash flows coming from creditworthy customers which give them long-term visibility over future debt repayments. In the case of TSEAD, the heating tariff is subject to annual regulatory approval. Whilst historically heating tariffs have remained relatively stable, this will likely be seen by lenders as a potential regulatory risk. Therefore, in order to obtain competitively priced debt for the Plan, it is likely that some level of long-term contractual revenue stability will need to be secured through a long term Power Purchase Agreement (PPA) for electricity production with one or more creditworthy counterparties.

Of course, a major variable affecting cash flow uncertainty is TSEAD's operating expense profile. For TSEAD, the two largest operating cost components are natural gas (~60% of total operating costs) and CO_2 emission credits (~30-35% of total operating costs). These two components are not only more than 90% of the operating costs, but also vary annually, thus further adding to cash flow volatility. Currently, the Company enters into annual gas purchase agreements with Bulgargaz and buys CO_2 emission credits on the open market. As discussed earlier, when considering natural gas as a fuel source, it is likely that lenders will favor a structure under which TSEAD is able to diversify its gas supply with the arrival of alternative gas supplies in volume commencing next year. Such diversity should result in substantially better pricing, significantly improved payment terms – thus reducing penalty interest expense – and less price volatility.

The final key consideration in the investment structure is the availability of a guarantee. TSEAD has seen its financial situation deteriorate over the last 10 years and has accumulated large amounts of debt as a result of its continuous operating losses. Lenders will view the Company as a non-investment grade borrower (below Baa3 according to Moody's and BBB- according to S&P) which limits both the amount of debt and the terms (interest rate and maturity) that they will be willing to extend to TSEAD. Furthermore, the Company lacks significant assets to post as additional collateral.

Marathon believes that it will be possible to substantially enhance the perceived counterparty risk of TSEAD through the use of 'bankable' PPA agreements for the increased electricity output with creditworthy buyers. The amount of contracted output will be sized to exceed the amount of funds required to amortize both the loans to implement the Plan as well as all accrued liabilities to BEH, thus providing maximum repayment security. This large and secure revenue stream may then be backed by an owner's guarantee on the part of the Sofia Municipality. Under such circumstances, TSEAD will be able to access competitively priced debt to fully fund the Plan at very low risk to the Municipality.

Our objective going forward will be to provide the maximum amount of financing on the best available terms at the least risk to the Municipality. Based upon our experience and initial interactions with potential lenders, we believe that objective is fully achievable.

6.0 Regulatory

6.1 Assessment of Alternative Management Structures

In general, day to day operations and maintenance (O&M) activities are conducted by plant level personnel, but major maintenance activities which cannot be performed by plant personnel (such as those requiring unique equipment, tools, or skills) are contracted out to third party service providers or equipment manufacturers. Based on discussions with TSEAD, TSEAD is currently required to execute a formal tender process for all major maintenance contracts. The lengthy formal tender process can cause delays in completion of major maintenance activities and commands a large amount of time and effort from staff. Additionally, since many service providers are involved in the tender process, the service providers selected through the tender process vary over time, resulting in inconsistency in maintenance approach.

Based Black & Veatch's observations within the industry, power generation and district energy companies have implemented a number of different maintenance contracting strategies to meet their specific needs, with the goals such as balancing cost, performance, services based on staff capabilities, speed, and flexibility. Potential alternative maintenance contracting strategies include options such as:

- Completion of formal tender process for planned major maintenance activities, with pre-approved list of service providers invited to bid. Utilization of on-call service agreements with list of preferred service providers for unplanned maintenance activities. Preferred service providers can be selected through a formal selection process and ranked based on criteria such as cost, response time, maintenance approach, etc. such that when an unplanned maintenance event occurs the plant can reach out to the appropriate preferred service provider(s).
- Implementation of parts and services agreements or long-term service agreements (LTSA) with service providers through a formal tender process. Parts and services agreements typically give the right to perform all services and supply all parts for a specific piece of equipment to a specific service provider. Through these agreements, the plant typically receives discounts on parts and services and may also receive response time or outage duration guarantees. Alternatively, a more comprehensive LTSA can be implemented. The benefits of an LTSA vary from project to project and depend on the actual terms and conditions negotiated into the agreement. These benefits need to be weighed against the costs associated with the LTSA. Some potential benefits of an LTSA include the following:
  - The ability to levelize major maintenance costs over time.
  - Possible performance guarantees which could include output, heat rate degradation, or availability guarantees including liquidated damages for underperformance and bonuses for outperformance.
  - Full coverage of certain components that are only inspected under a parts and services agreement as well as potential coverage of auxiliary equipment.
  - More comprehensive coverage reducing the likelihood of dispute in the event of a failure causing collateral damage and repair of collateral damage.
  - Additional services including spare parts inventory management, coordination of outage scheduling, handling of warranty claims, consultation regarding updating equipment to comply with technical information letters (TILs), and notification of upgrades available to enhance performance or reliability.

Black & Veatch notes that LTSAs are typically available for major equipment such as gas turbines or steam turbines, although those LTSAs can additionally cover equipment such as HRSGs, transformers, and generators, especially for recently constructed projects where much of this major equipment may be provided by a single original equipment manufacturer (OEM). Parts and services agreements or other types of service agreements are typically utilized for older equipment and equipment other than prime movers such as gas turbines or steam turbines.

6.2 Assessment of TSEAD's Role in the National Electrical Power Systems

In development of the Plan, Black & Veatch and its partners have fully understood that the primary role of TSEAD is to provide hot water to its customers. With that consideration, the Plan is designed to generate only the amount of additional electric power that ensures financial stability for TSEAD.

However, with the significantly higher electrical generation compared to current levels, at an effective efficiency higher than any conventional generation in Bulgaria, TSEAD can play an important role in the National Electric Power System.

The Plan is based on detailed inputs received from national electric grid operator ("ESO") on the optimal grid interconnection solutions for the cogeneration plants as well as on the locations that will be most useful to the grid operator for maintaining the grid stability. Lyulin was chosen as a preferred site for cogeneration because according to ESO it will increase the grid stability and reduce the congestion in the transmission network in that area. Therefore, if planned appropriately and in collaboration with the grid operator, TSEAD can have a large role in the national electric power system.

7.0 Conclusion

The current operational and financial condition of TSEAD is dire. The number and enormity of the company's challenges requires a large scale and comprehensive remediation program. We believe the proposed Plan fully meets that requirement and is fully achievable.

Black & Veatch and its partners are concurrently working on developing financing program for the Plan. Once the Plan is approved by the Client, Black & Veatch and its partners will move to the next phase of study that includes the following tasks that will be conducted in accordance with the Contract and Work Plan:

- Task 4: Legal and Management Structure Assessment and Recommendations
- Task 5: Regulatory Review of the Plan
- Task 6: Advanced Metering Infrastructure Assessment and Recommendations
- Task 7: Preliminary Environmental and Social Impact Assessment of the Plan
- Task 8: Preliminary Development Impact Assessment of the Plan
- Task 9: Sources of Supply for Plan Implementation
- Task 10: Public Summary
- Task 11: Final Report

Once Plan is approved and the Study is completed, we would expect that necessary planning will take approximately 6 to 9 months, and construction an additional 30 months. Thereafter TSEAD will be fully capable of providing reliable, affordable heat in a financially sustainable and environmentally compliant way for at least 25 years.

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