तेल एवं गैस उत्पादन प्रौद्योगिकी संस्थान

Institute of Oil and Gas Production Technology

पनवेल, नवी मुंबई

Panvel, Navi Mumbai

Project Report

on

टैंकर लोडिंग साइट्स पर असोसिएटेड गैस की रिकवरी पर वैचारिक अध्ययन

Conceptual Study on Recovery of Associated Gas at Tanker Loading Sites

जनवरी – 2023

तेल एवं गैस उत्पादन प्रौद्योगिकी संस्थान
Institute of Oil and Gas Production Technology

पनवेल, नवी मुंबई

Panvel, Navi Mumbai

कं. सं.: IO.22I.PT_AM.003S **दिनांक: 03/03/2023**

विषय: टैंकर लोडिंग साइट्स पर असोसिएटेड गैस की रिकवरी पर वैचारिक अध्ययन

Subject: Conceptual Study on Recovery of Associated Gas at Tanker Loading Sites

" **टैंकर लोडिंग साइट्स पर असोसिएटेड गैस की रिकवरी पर वैचारिक अध्ययन** " रिपोर्ट की प्रति आपके अवलोकनार्थ एवं संदर्भ के लिए संलग्न की गई है।

Please find enclosed a copy of the report on "**Conceptual Study on Recovery of Associated Gas at Tanker Loading Sites**" for your kind perusal.

नितिन. बी. जोशी

Nitin. B. Joshi

Head of Department, SF & PE

वितरण / Distribution :

1. परिसंपत्ति प्रबंधक, अहमदाबाद परिसंपत्ति / Asset Manager, Ahmedabad Asset
2. भूतल प्रबंधक, अहमदाबाद परिसंपत्ति / Surface Manager, Ahmedabad Asset
3. आईओजीपीटी समन्वयक, अहमदाबाद परिसंपत्ति / IOGPT Coordinator, Ahmedabad Asset

तेल एवं गैस उत्पादन प्रौद्योगिकी संस्थान

Institute of Oil and Gas Production Technology

पनवेल, नवी मुंबई

Panvel, Navi Mumbai

Project No: IO.22I.PT_AM.003S

Acc No: 3102

टैंकर लोडिंग साइट्स पर असोसिऐटेड गैस की रिकवरी पर वैचारिक अध्ययन

Conceptual Study on Recovery of Associated Gas at Tanker Loading Sites

कार्यकेंद्र:	**अहमदाबाद परिसंपत्ति**
Work Centre:	**Ahmedabad Asset**
मुख्य अन्वेषक:	बी वर्षा, मुख्य अभियंता (उ)
Chief Investigator:	B Varsha, CE(P)
सह–अन्वेषक:	मनीष गुप्ता, अधीक्षण अभियंता (उत्पादन)
Co-investigator:	Manish Gupta, SE(P),
	अमन शर्मा, कार्यकारी अभियंता (उ),
	Aman Sharma, EE (P),
प्रभारी:	वी के सिंह, महाप्रबंधक (उ)
Incharge:	V K Singh, GM (P)
कार्य संघ:	शिल्पी गर्गमुख, अधीक्षण अभियंता (उ)
Work Association:	Shilpy Gargmukh, SE (P), Ahmedabad Asset
समीक्षित:	एन बी जोशी, मुख्य-महाप्रबंधक (उ) –विभागाध्यक्ष
Reviewed by:	N B Joshi, CGM (P) – HOD
अनुमोदित	राजीव निश्चल, समूह महाप्रबंधक- संस्थान प्रमुख
Approved by	Rajiv Nischal, GGM-HOI

Institute of Oil and Gas Production Technology
Panvel, Navi Mumbai

Executive Summary

This pertains to the scheduled project titled "**Conceptual Study on Recovery of Associated Gas at Tanker Loading Sites**" taken up by IOGPT under AWP 2022-23, at the behest of Ahmedabad Asset.

Wadsar#6 well site receives around 51 m^3/day of liquid and 800 SCMD of gas from 9 SRP wells under Wadsar field. The well fluid is collected in 1 no. of 45 m^3 and 2 no. of 35 m^3 local storage tanks at the well site. Hired Mobile Steaming Units (MSU) are used to heat the well fluid in the storage tanks to prevent congealing and facilitate pumping for further transportation to installation through road tankers. Presently, Asset intends to comply with the audit observation, i.e., to separate oil and gas at the well site and to safely handle the recovered associated gas. Accordingly, IOGPT reviewed the existing setup and conceptualized facilities as below:

- Existing 35 m^3 open tanks to be replaced with 2 no. 45 m^3 cylindrical tanks.
- Further, for recovery of associated gas, various technologies such as gas to micro turbine, compressed gas to nearby existing gas grid, gas to CNG, are explored. Of these, due to lesser associated gas amount and LAQ issues, gas to micro turbine is found to be suitable in the instant case. Accordingly, for gas to micro turbine system vis-à-vis well fluid heating, three options were studied:
    - In option-1, capturing associated gas as vent gas from storage tanks, broad facilities such as booster compressors and micro turbine are envisaged and MSU for well fluid heating. Ballpark CAPEX is ₹ 4.61 Cr and OPEX per year is ₹ 0.74 Cr.
    - In option-2, recovery of associated gas using separator and then routing gas to micro turbine, broad facilities such as separator and micro turbine are envisaged and MSU for well fluid heating. Ballpark CAPEX is ₹ 3.82 Cr and OPEX per year is ₹ 0.56 Cr.
    - In option-3, recovery of associated gas using separator and then routing gas to micro turbine, broad facilities such as separator, micro turbine are envisaged. Additionally, bath heater is envisaged for well fluid heating. Ballpark CAPEX is ₹ 4.09 Cr and OPEX per year is ₹ 0.14 Cr.
    - Utilities such as flare system and firefighting system are envisaged and included in all the options.

Hence, option-3, gas to micro turbine by recovering associated gas using a new separator & new bath heater for heating well fluid is recommended. The power generation will be ~45 kW, which can used for internal consumption. Also, the scheme will reduce hydrocarbon emissions. The details are brought out in the report.

Rajiv-Nischal.

Rajiv Nischal
GGM-HOI IOGPT

Contents

1.0 Background

There are 47 wells in Wadsar Field, all located in 6 different cluster well sites namely Wdsr#1, Wdsr#5, Wdsr#6, Wdsr#43, Wdsr#8 and Wmj#14. Presently around 275 m^3/d of liquid production from the wells of the field is collected in local tanks at cluster sites and is evacuated through road tankers and unloaded at Sanand GGS-I & GGS-II installations.

Asset informed that the quality of Wadsar crude is such that it requires steam heating even in summers (Pour point of 39-42 ^{0}C). Mobile Steaming Units (MSU) are deployed for heating of emulsion in local tanks. Chemical dosing is also done at well site for flow assurance.

The following observation has been brought out by the audit team, for compliance:

Quote

"Regulation 62, Regulation 95 and 129 (7) (a and b) read with DGMS Technical Circular no.1 of 2019 clause no. 6: Crude (Gas & Oil) produced from cluster well no. WSR#6, WSR#7, WSR# 14, WSR#18, WSR#39, WSR#40, WSR#42 and WSR# 47; situated at adjacent to CW-50-X work over Rig, (well WSR#41) at Village: Moti Bhoyan Taluka: Kalol District Ahmedabad (Gujarat state); were not being separated and not being safely handled or conduit or disposed off after being burnt through flare stack. Oil and gas was being directly discharged into an open top storage tank. Therefore, immediate step shall be taken to separate oil and gas and safely conduit/handled or disposed off after burning through a suitable flare stack".

Unquote

Accordingly, Asset requested scheme for recovery of associated gas at Wadsar#06 well site and the study titled "Conceptual Study on Recovery of Associated Gas at Tanker Loading Sites" has been taken up by IOGPT as scheduled project in AWP 2022-23.

1.1 Existing system at Wadsar#6 wellsite:

The well site receives well fuid from nine SRP wells under Wadsar field. The well fluid is routed to 1 no. of 45 m^3 and 2 no. of 35 m^3 local storage tanks at the well site through field header. Hired Mobile Steaming Units (MSU) are used to heat the well fluid in the storage tanks to prevent congealing. During heating by MSU, steam hose is directly put into the tank for 1-2 hr to increase the temperature up to 45-48°C. After heating, crude oil mixture is dispatched through road tankers to installation. The schematic of well fluid handling at remote well site is as shown in Figure 1.1.

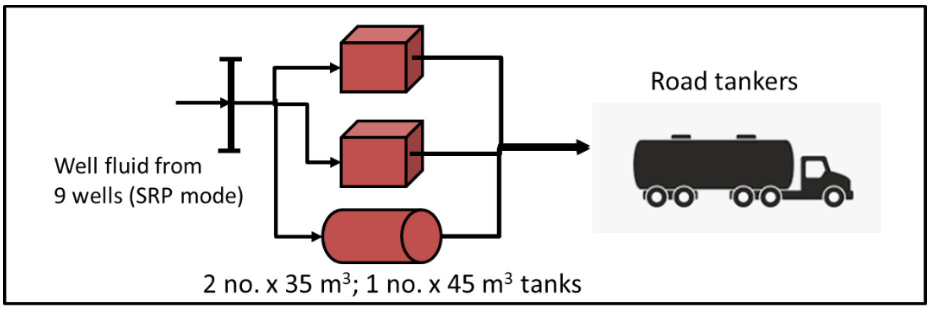

Figure 1.1: Schematic of Well fluid handling at Wadsar#6 Well site

2.0 Scope of work

- Review of existing system
- Simulation studies
- Literature survey and technology scouting
- Analysis of the available technologies for recovery and utilization of low pressure gas from storage tanks prior to loading into tanker
- Scheme Conceptualization

3.0 Basis of study

The input data such as present liquid and gas quantities, gas composition, crude oil analysis etc. provided by the Asset are considered for the study. The details are briefed below:

3.1 Present liquid and gas quantities

The well site receives 51 m^3/day liquid and 800 SCMD gas under Wadsar Field. The wellwise production of liquid and gas quantities are shown in Table 3.1.

Table 3.1: Present liquid and gas quantities handling at Wadsar#06 well site

Sl	Well No	Liquid (m^3/d)	Water Cut	Oil (m^3/d)	Water (m^3/d)	No. of tanks		Gas (SCMD)
						35 m^3	45 m^3	
1	WSR#6	2.0	66	0.7	1.3			13.6
2	WSR#7_Z	0.0	0	0.0	0.0			0.0
3	WSR#14	4.0	7	3.7	0.3			74.4
4	WSR#18	7.0	67	2.3	4.7			46.2
5	WSR#39	8.0	6	7.5	0.5	2	1	150.4
6	WSR#40	8.0	6	7.5	0.5			150.4
7	WSR#41	3.0	8	2.8	0.2			55.2
8	WSR#42	6.0	52	2.9	3.1			57.6
9	WSR#47	13.0	6	12.2	0.8			244.4
	Total	51		39.6	11.4			800

Gas quantity is calculated based on GOR of 20 Sm^3/m^3.

3.2 Gas composition is given in Table 3.2.

Table 3.2: Gas composition	
Components	Mole, %
Methane	94.708
Ethane	1.187
Propane	0.412
i-Butane	0.197
n-Butane	0.062
i-Pentane	0.059
n-Pentane	0.048
n-Hexane+	1.986
CO2	1.129
Nitrogen	0.212
Molecular Weight	18.23
Source: Wadsar#18 well	

3.3 Crude oil analysis:

i. Water Cut (%v/v) : 50

ii. Free Water : Traces

iii. Density (kg/m^3) : 905.3

iv. API Gravity : 24.72

v. Pour Point (^{o}C) : 39

vi. Distillation Profile: ASTM–D86 Data given in Table 3.3.

Table 3.3: Crude Oil Distillation Data	
IBP	145°C
Temperature Range, from IBP to	Recovery % volume (Cumulative) ml
75°C	-
100°C	-
125°C	-
150°C	1.0
175°C	5.0
200°C	8.0
210°C	9.0
225°C	11.0
250°C	19.0
275°C	27.0
300°C	43.0

vii. Viscosity Profile

Table 3.4: Viscosity Profile		
Temperature, ^{0}C	Shear rate, sec^{-1}	Viscosity, cp
51	10	189.68
48	10	220.68
45	10	259.36
42	10	339.10
39	10	591.06
36	10	2111.10
33	10	8221.30
30	10	24724.00
27	10	83554.00
24	10	227270.00
21	10	355040.00
18	10	494230.00

4.0 Scheme for recovery of Associated Gas at Tanker Loading site

4.1 To comply to the regulations,

New 2 no. x 45 m^3 tanks are envisaged along with existing 1 no. x 45 m^3 tank.

4.2 For recovering associated gas, following technologies are available:

- Gas to micro turbine
- Gas to CNG
- Gas to nearby existing gas grid using gas compressors

The technologies are briefed below:

4.2.1 Gas to micro turbine

Micro turbine is a type of combustion turbine that produces both heat and electricity on a relatively small scale. It offers technologies for small-scale power generation, consists of a small number of moving parts, compact size, lower emissions, lower electricity costs and opportunities to utilize waste fuels. Because of their small size, relatively low capital costs, expected low operations and maintenance costs, automatic electronic control, micro turbines are efficient and clean solution for small scale power generation purposes.

Most of the micro turbines comprise of a compressor, combustor, turbine, alternator, recuperator (a device that captures waste heat to improve the efficiency of the compressor stage) and generator.

Micro turbines work like jet engines but produce electricity instead of thrust.

i. Fuel enters the combustion chamber and is burnt resulting in turbine rotation.
ii. The hot combustion gases spin turbine which is connected to the shaft of an electrical generator and the exhaust heats up the inlet air.
iii. Air passes through a compressor and is heated by exhaust gas before going to combustion chamber.

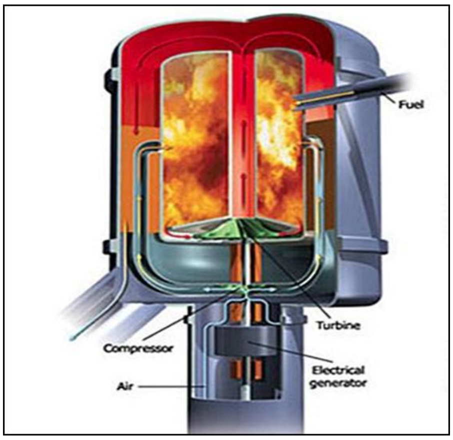

Figure 4.1: Working principle of microturbine

A schematic diagram of the micro turbine is shown in Figure 4.2.

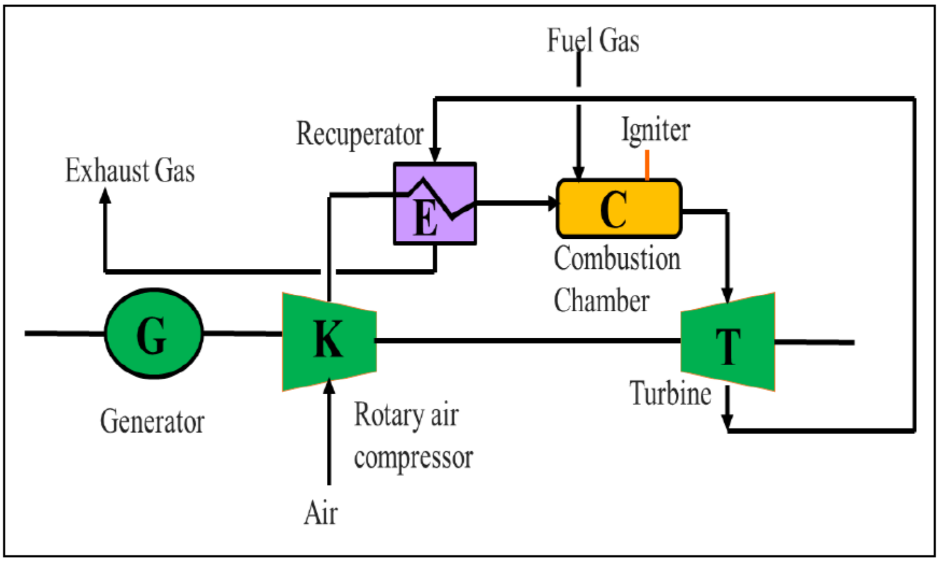

Figure 4.2: Schematic of Microturbine

4.2.2 Gas to Compressed Natural Gas (CNG)

Compressed Natural Gas (CNG) is gaseous, consisting of about 80 to 90 per cent methane and is currently used as an alternative automotive fuel. CNG is produced by compressing natural gas to less than 1% of its volume at standard atmospheric pressure. Transportation of gas through containers is general approach for transportation of gas from CNG plant to consumer. Automotive CNG delivery pressure of 250 barg is generally adhered to in the industry. Required Specifications for CNG is Automotive CNG specifications as per IS-15958.

In the instant case, due to lesser amount of produced associated gas at well site, Gas to CNG is not feasible as gas compressors of minimum capacity of 4800 SCMD CNG are available in market.

4.2.3 Gas to nearby existing gas grid using gas compressors

Asset informed the recovered associated gas cannot be routed to nearby existing gas grid due to remote location/LAQ issues.

In the instant case, gas to nearby existing gas grid using gas compressors is not feasible.

Of the available technologies such as gas to micro turbine, gas to CNG and gas routing to nearby existing gas grid using gas compressors, gas to micro turbine is found to be suitable in the instant case due to lesser associated gas amount and LAQ issues. Accordingly, scheme for gas to microturbine is further explored and is detailed below.

4.3 Scheme for Gas to Micro Turbine system vis-à-vis well fluid heating:

For gas to micro turbine system vis-à-vis well fluid heating, following three options are explored:

- Option-1: Gas to micro turbine: Capturing as vent gas from storage tanks
- Option-2: Gas to micro turbine: Recovery of associated gas using separator and then gas to micro turbine
- Option-3: Gas to micro turbine: A bath heater, new separator and micro turbines are envisaged.

The scheme details of each option are described below:

4.3.1 Option-1: Gas to micro turbine: Capturing as vent gas from storage tanks

In this option, associated gas is recovered as vent gases from storage tanks. Well fluid will be routed to well site tanks (1 no. 45 m^3 and 2 new 45 m^3 tanks) through field header (same as existing system). Booster compressors and micro turbine for power generation using gas are envisaged for recovery of associated gas (as vent gas from well site storage tanks).

Booster compressors will be utilized to capture the vent gas from the storage tanks and will be compressed up to a pressure of 5 kg/cm^{2}g. The compressed gas is then routed to micro turbine for power generation. The schematic of gas to micro turbine system using vent gas from storage tanks is shown in Figure 4.3.

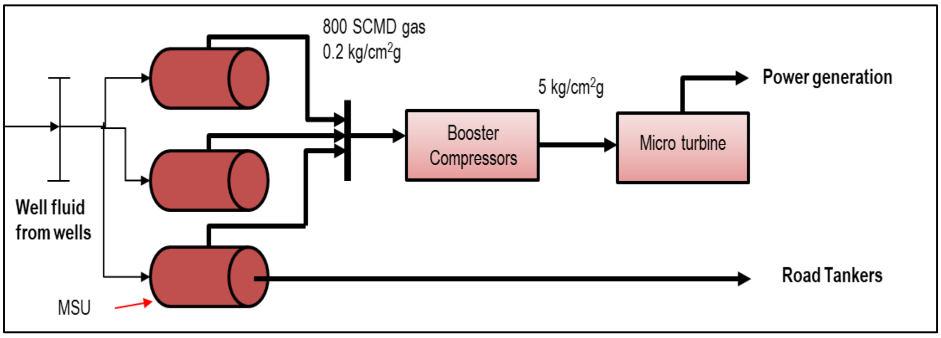

Figure 4.3: Schematic of gas to micro turbine system using vent gas from storage tanks

However, for well fluid heating, existing storage tank has 2'' steam coil which can be used for steaming purpose. Steaming unit will be used for the same.

Broad facilities comprise of 2 no. of 45 m^3 tanks, Booster compressors (1 operating + 1 standby), Micro turbine (1 no.), Flare system, Firefighting system, Steaming unit for well fluid heating in storage tanks.

4.3.2 Option-2: Gas to micro turbine: Recovery of associated gas using separator

In this option, associated gas will be recovered using separator. New facilities such as a separator and a microturbine for power generation using gas are envisaged. Well fluid will be gathered in a field header and then routed to a separator for separation of gas and liquid. Separator will be operating at pressure of 5 kg/cm²g. The separated gas is then routed to micro turbine for power generation. The schematic of gas to micro turbine system for recovery of associated gas using separator is shown in Figure 4.4.

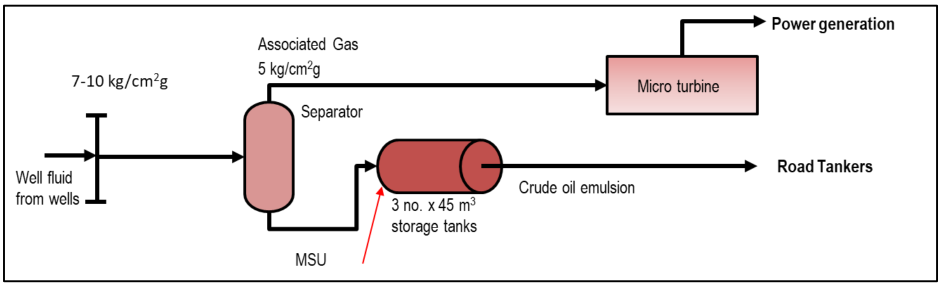

Figure 4.4: Schematic of gas to micro turbine system for recovery of associated gas using separator

However, for well fluid heating, existing storage tank has 2'' steam coil which can be used for steaming purpose. Steaming unit will be used for the same.

Broad facilities comprise of 2 no. of 45 m³ tanks, gas-liquid separator, Micro turbine (1 no.), Flare system, Firefighting system, Steaming unit for well fluid heating in storage tanks.

4.3.3 Option-3: Gas to micro turbine: Recovery of associated gas using bath heater, separator

In this option, associated gas will be recovered using bath heater and separator. New facilities such as bath heater, separator & a microturbine for power generation using gas are envisaged. Well fluid will be gathered in a field header and then routed to bath heater for heating the well fluid. The heated well fluid from bath heater will then be routed to separator for separation of gas and liquid. Separator will be operating at pressure of 5 kg/cm²g, separated gas from which is routed to the micro turbine for power generation. The schematic of gas to micro turbine system for recovery of associated gas using separator is shown in Figure 4.5.

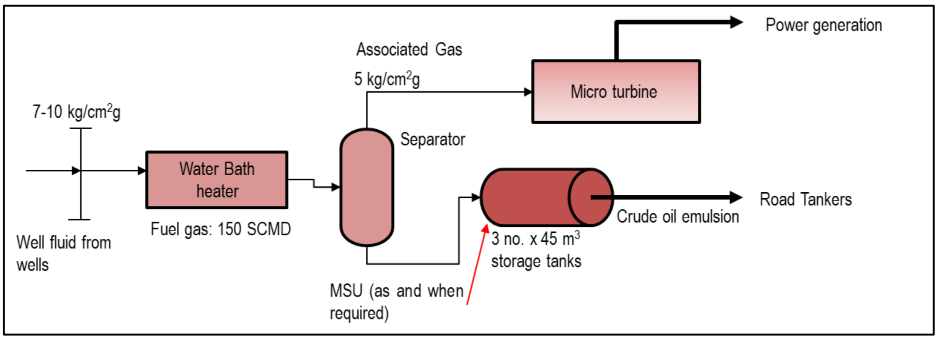

Figure 4.5: Schematic of gas to micro turbine system for recovery of associated gas using bath heater and separator

In this option, bath heater is used for heating well fluid. However, mobile steaming unit might be needed for tank heating as and when required.

Broad facilities comprise of 2 no. of 45 m^3 tanks, bath heater, gas-liquid separator, Micro turbine (1 no.), Flare system, Firefighting system. Steaming unit for well fluid heating in storage tanks will be used as and when required.

4.3.4 Cost comparison of facilities required in various options

Cost estimate of facilities required in various options is summarized in Table 4.1.

Table 4.1: Summary of cost estimate of facilities required in various options

Facilities	**Option-1**	**Option-2**	**Option-3**
	Gas to micro turbine by capturing as vent gas from storage tanks	Gas to micro turbine by recovering associated gas using separator	Gas to micro turbine by recovering associated gas using bath heater, separator
Required I/L pressure/THP	1.5-3.5 kg/cm^2	7-10 kg/cm^2	7-10 kg/cm^2
Water bath heater	--	--	Yes
Separator	--	Yes	Yes
Booster compressor	Yes	--	--
Micro turbine	Yes	Yes	Yes
2 no. x 45 m^3 Tanks	Yes	Yes	Yes
MSU	Required	Required	*As & when required
Utilities			
Flare system	Yes	Yes	Yes
Fire water system	Yes	Yes	Yes
Ballpark cost estimates			
CAPEX	₹ 4.61 Cr	₹ 3.82 Cr	₹ 4.09 Cr
OPEX	₹ 0.74 Cr	₹ 0.56 Cr	₹ 0.14 Cr
Ballpark cost estimates of the pipelines have been carried out based on the available in-house cost data. This cost will be required to be updated by Asset based on the real time cost database of Engineering Services before taking approval for field implementation.			

5.0 Summary

- Wadsar#6 well site receives around 51 m^3/day liquid and 800 SCMD gas from 9 SRP wells under Wadsar Field. The well fluid is collected in 1 no. of 45 m^3 and 2 no. of 35 m^3 local storage tanks at the well site. Hired Mobile Steaming Units (MSU) are used to heat the well fluid in the storage tanks to prevent congealing and facilitate pumping for further transportation to installation through road tankers.
- Presently, Asset intends to comply with the audit observation, i.e., to separate oil and gas at the well site and to safely handle the recovered associated gas.
- Accordingly, the existing setup is reviewed and conceptualized facilities as below:
  - Existing 35 m^3 open tanks to be replaced with 2 no. 45 m^3 cylindrical tanks having safe relieving system.
  - Further, for recovery of associated gas, various technologies such as gas to micro turbine, compressed gas to nearby existing gas grid, gas to CNG, are explored. Of these, due to lesser associated gas amount and LAQ issues, gas to micro turbine is found to be suitable in the instant case. Accordingly, for gas to micro turbine system vis-à-vis well fluid heating, three options were studied:
    - In option-1, capturing associated gas as vent gas from storage tanks, broad facilities such as booster compressors and micro turbine are envisaged and MSU for well fluid heating. Ballpark CAPEX is 4.61 Cr and OPEX is 0.74 Cr.
    - In option-2, recovery of associated gas using separator and then routing gas to micro turbine, broad facilities such as separator and micro turbine are envisaged and MSU for well fluid heating. Ballpark CAPEX is 3.82 Cr and OPEX is 0.56 Cr.
    - In option-3, recovery of associated gas using separator and then routing gas to micro turbine, broad facilities such as separator, micro turbine are envisaged. Additionally, bath heater is envisaged for well fluid heating. Ballpark CAPEX is 4.09 Cr and OPEX is 0.14 Cr.
    - Utilities such as flare system and firefighting system are envisaged and included in all the options.
- Hence, gas to micro turbine by recovering associated gas using a new separator & new bath heater for heating well fluid is recommended. The power generation will be ~53 kW, which can used for internal consumption. Also, the scheme will reduce methane emissions.

तेल एवं गैस उत्पादन प्रौद्यौगिकी संस्थान

Institute of Oil and Gas Production Technology

फेस-II, पनवेल, नवी मुंबई - 410221
Phase-II; Panvel, Navi Mumbai - 410221
दू. : 91-22-27451891, फ़ैक्स : +91-22-27451690

पंजीकृत कार्यालय : दीन दयाल ऊर्जा भवन, 5 नेल्सन मंडेला मार्ग
वसंत कुंज , नई दिल्ली - 110070
Registered Office: Deendayal Urja Bhavan, 5 Nelson Mandela Marg
Vasant Kunj, New Delhi- 110 070, (India)
दू.: 91-11-26750999, 26129000. Fax: 91-11-26129091