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One Phase Well Design for Minimum Drilling Cost at ZAZ Field

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ABSTRACT - Drilling cost components including rig, casing and accessories, well surface equipment, drilling mud, bits, cementing, and casing installation substantially influence the overall drilling cost. The One Phase Well (OPW) design is implemented by eliminating the surface casing, which is conventionally applied in casing designs for wells in the ZAZ Field. This study evaluates drilling parameters such as well data, well trajectory, pore pressure–fracture gradient, drilling time, material usage, and drilling costs. A well profile analysis is conducted to compare the Three Phase Well (TPW) and One Phase Well (OPW) designs. The analysis of drilling time, materials, and drilling costs is conducted to evaluate the cost reduction difference between the Three Phase Well (TPW) method and the One Phase Well (OPW) method.. The OPW design reduces rig rental costs by 34.9%, bit costs by 53.9%, casing costs by 20.5%, wellhead costs by 8.7%, and mud costs by 3.7%. In contrast, cementing costs increase by 0.7%, and casing installation incurs an additional cost of USD 24,017. Overall, the total drilling cost difference between OPW and TPW amounts to USD 68,633, with OPW achieving a 12.7% reduction in overall drilling costs compared to TPW.

Keywords: three hase well method, one phase well method, drilling expenditure, cost efficiency..

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INTRODUCTION

The ZAZ Field is located in the South Sumatra Basin, one of Indonesia's prominent hydrocarbon-producing regions. According to Julikah et al. (2020), this basin was formed as a back-arc basin through tectonic interactions between the Indo-Australian and Eurasian Plates during the Pre-Tertiary and Early Tertiary periods. The basin contains over 100 oil and gas fields, many of which are still operational. Figure 1 illustrates the sub-basins of the South Sumatra Basin. The basin is divided into four sub-basins: North Palembang, South Palembang, Central Palembang, and Jambi (Julikah et al., 2020). The North Palembang sub-basin is particularly notable for its hydrocarbon-rich sandstone reservoirs within the Talang Akar Formation (TAF), which have yielded substantial amounts of oil and gas (Julikah et al., 2015). Drilling operations in the ZAZ Field targeted the productive TAF-C layer. Several procedures are employed to optimize drilling wells, including collecting high-quality well data, performing formation correlation analyses, and comparing rotating and non-rotating times from correlation wells to determine the most efficient well design. Primary optimization compares the cost per foot and the rate of penetration (ROP) of drilled wells at varying depths, while secondary optimization involves applying computational methods to refine drilling parameters. Combining these approaches yields final optimization, enabling an optimal well design (Bahari & Seyed 2007). This process can reduce drilling time and cost per foot by 30–80% compared to previous drilling methods.

The main challenge in maintaining a lower cost per foot is implementing competitive well designs to counteract rising material and drilling service costs, particularly in low-reservoir-productivity structures. Adjustments can include adopting slick bottom-hole assemblies (BHA) to increase penetration rates on favorable hole trajectories, optimizing casing designs to minimize the number of casing strings, and extending open-hole sections to depths exceeding 11,000 feet. Additional measures involve refining drilling mud systems to enhance hole stability, selecting compatible drill bits for specific formations, and optimizing cement designs to seal formations with low fracture pressure effectively. Employing cost-effective and high-quality cement can also mitigate gas migration risks during the transition period. Streamlining rig movements and maximizing rig utilization further enhance operational efficiency and safety, particularly when implementing smaller hole designs (Bakly et al., 2007).

Casing costs, a significant portion of well construction expenses, can be minimized by selecting optimal casing string configurations tailored to various load conditions in vertical and directional wells. Studies indicate that optimizing casing designs can reduce drilling costs by 24% compared to conventional methods (Wojtanowicz et al., 1987). These savings are achieved by employing smaller casing sizes, selecting appropriate casing materials, and determining the optimal number of casing strings required to reach the target depth (Halal et al., 1996).

Oumer et al. (2010) demonstrated that eliminating one series of casing strings could significantly reduce

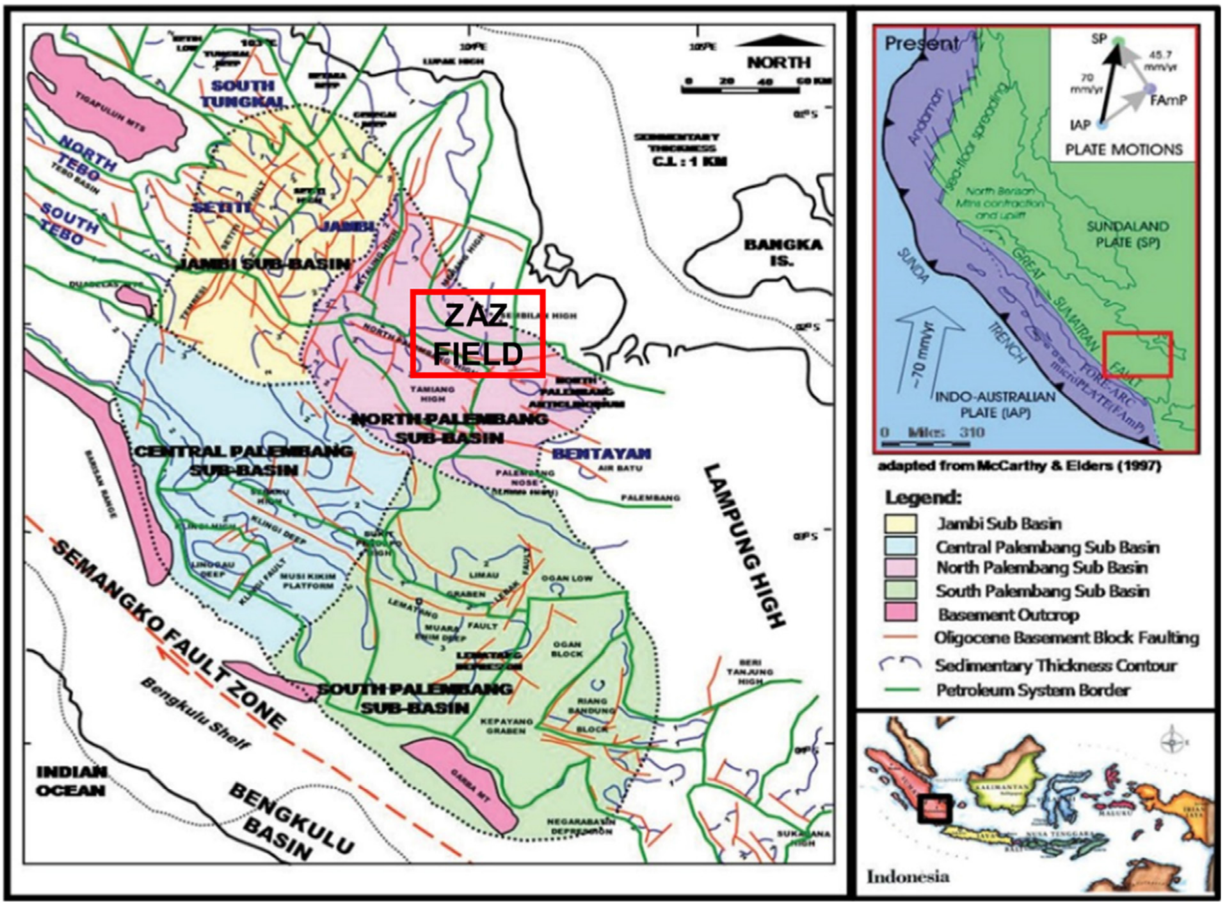

Figure 1. Regional tectonic map of the South Sumatra Basin, Indonesia (Julikah et al. 2020).

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drilling costs. For instance, using three casing strings with optimized sizes and weights shortened drilling times by 10% compared to conventional methods, while using two casing strings reduced drilling time by 30%. Oumer et al. (2012) also emphasized the importance of innovation, new technology, and team performance in achieving long-term cost reductions. Their study highlighted how well construction efficiency could be enhanced by modifying well trajectory designs, selecting appropriate casing and bit sizes, and incorporating advanced technologies such as oil-based mud, polycrystalline diamond compact (PDC) bits, rotary steerable systems (RSS), and casing drive systems. By implementing these methods, drilling durations decreased significantly, from 55 days to just 17 days in certain projects. Rahanjani et al. (2020) emphasized the value of real-time data transmission and visualization as advanced technologies for reducing drilling time. These systems enable real-time calculations of reservoir characteristics during geosteering and aid in determining drilling time, formation tops, and casing points. By minimizing non-productive time, these technologies significantly improve the efficiency of drilling operations, particularly in multi-well projects.

In the ZAZ Field, drilling operations employ water-based mud with KCl polymer as a shale inhibitor. The TAF consists of fluvial-deltaic deposits characterized by sandstones interbedded with shale and coal layers. Potential drilling challenges include encountering gas from coal seams and instability caused by shale. These issues are mitigated by using KCl polymer to stabilize the shale. To ensure the mud formulation meets field requirements, laboratory-scale testing is conducted to design the appropriate additives for addressing anticipated drilling challenges (Emanuella W.Y.P. et al., 2010).

Research by Handoko et al. (2017) demonstrated that using simpler well designs could improve casing cost efficiency, resulting in savings of up to 30%. Similarly, Shahin (2018) found that transitioning to slimmer casing designs and utilizing drilling-with-casing technology reduced drilling costs by 37% and shortened drilling times by over 45%. These findings underscore the potential of slimmer casing designs to support more efficient drilling operations and cost-effective rig usage. Cost-effective drilling methods, such as One Phase Well (OPW) designs, have been successfully implemented for shallow gas reservoirs. OPW simplifies the drilling process by eliminating surface casing and employs bit sizes distinct from the drill pipe to optimize well cleaning and minimize drilling fluid costs (Hanif et al., 2021; Wibowo et al., 2022). In the ZAZ Field, where the conventional Three Phase Well (TPW) method entails high drilling costs, transitioning to OPW presents a viable solution. This study evaluates the economic and technical feasibility of OPW for cost reduction in the ZAZ Field, focusing on critical drilling cost components such as rig costs, casing and accessories, surface equipment, mud, bits, cementing, and casing installation.

METHODOLOGY

This study was conducted in several stages: data collection, analysis and evaluation, and conclusion. A detailed workflow of the research process is presented in Figure 2.

Wells drilled in the ZAZ Field traditionally used a Three Phase Well (TPW) design, which incorporates three casing strings: conductor casing, intermediate casing, and production casing. However, this design led to high drilling costs and often failed to meet feasibility thresholds in drilling programs. To address this issue, a One Phase Well (OPW) design was developed by eliminating the intermediate casing, thereby reducing both drilling time and costs. The data used in this study include well data, well profiles, formation data, and operational data. Well data consists of well location, well type, elevation, ground level, datum depth, rig type, and rig capacity. Well profiles and formation data comprise well depth, well cross-sections, pore pressure fracture gradient (PPFG), formation depth, and formation characteristics. Lastly, operational data includes the Daily Drilling Report (DDR), casing data, bit records, survey data, mud program, cementing program, drilling parameters, and drilling time.

The study began by identifying and analyzing well data and drilling cost components that significantly contribute to high expenses in the ZAZ Field. Drilling cost evaluations for the OPW design were conducted by analyzing casing design, drilling time, and total costs. The results were then compared to those of the TPW design. If the cost analysis revealed that the OPW design resulted in higher costs than the TPW, a redesign of the casing would be conducted, followed by a re-evaluation and re-analysis of drilling time and costs. If the OPW design demonstrated cost savings, it would be recommended for future use in the ZAZ Field.

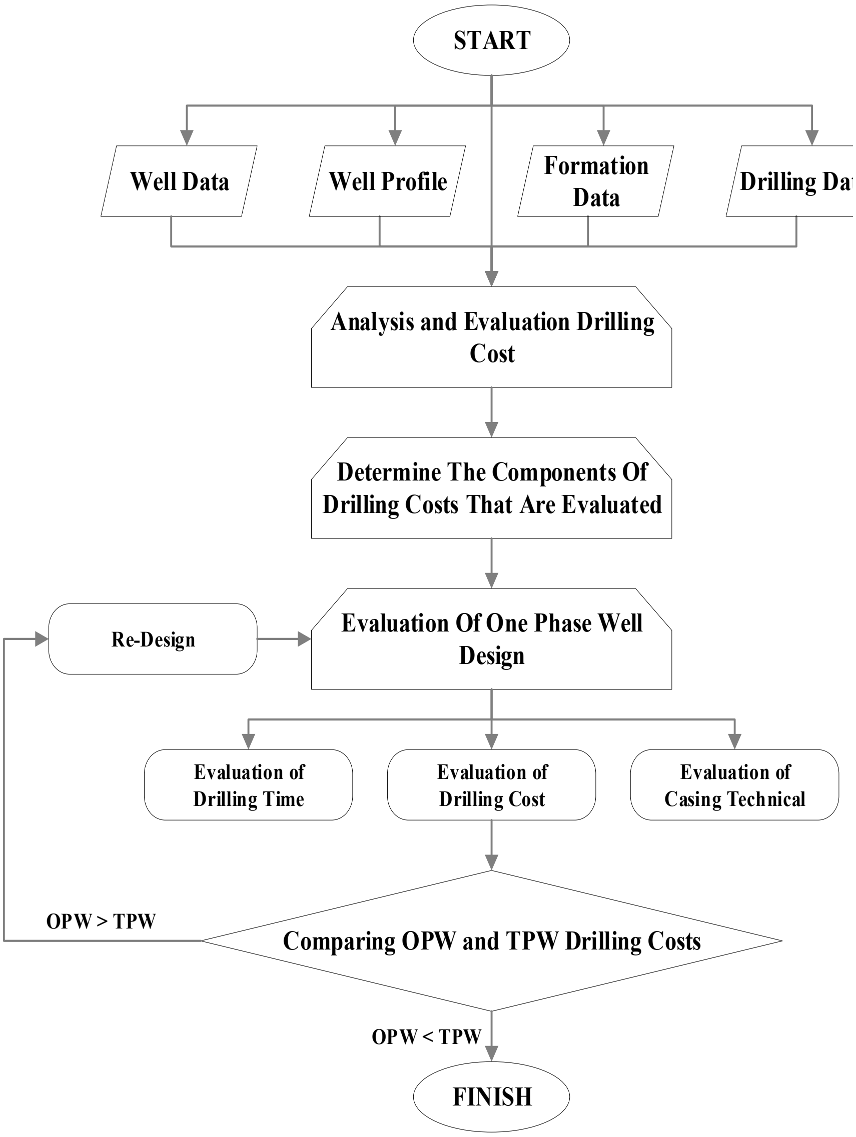

Figure 2. Workflow to analyze One Phase Well (OPW) design.

Well data and well profile

Two wells in the ZAZ Field were analyzed and evaluated. Those wells are Three Phase Well (TPW) architecture (ZAZ-24) and One Phase Well (OPW) architecture (ZAZ-32). Key well data are presented in Table 1, and the well profiles for ZAZ-24 and ZAZ-32 are shown in Figures 3 and Figure 4, respectively. A 550 HP derrick rig was used for both wells, with a rental cost of $642 per hour.

Data of pore pressure fracture gradient

Pore Pressure Fracture Gradient (PPFG) data needs to be known to determine the casing design and also the mud that will be used in drilling operations. Figure 5 and 6 show the PPFG graphs of ZAZ-24 and ZAZ-32 at the ZAZ Field.

Table 1. Well data at ZAZ field

Well Name	ZAZ-24	ZAZ-32
Type of Well	Directional	Directional
KOP, m	550	300
Inclination, deg	11.82	5.5
Rig Capacity, HP	550	550
Main Target	TAF-C	TAF-C
TDepth, mTVDSS	1216	1210
Operation Days, Day	23.1	25.5
Well Cost, USD	2,295,636	2,099,317

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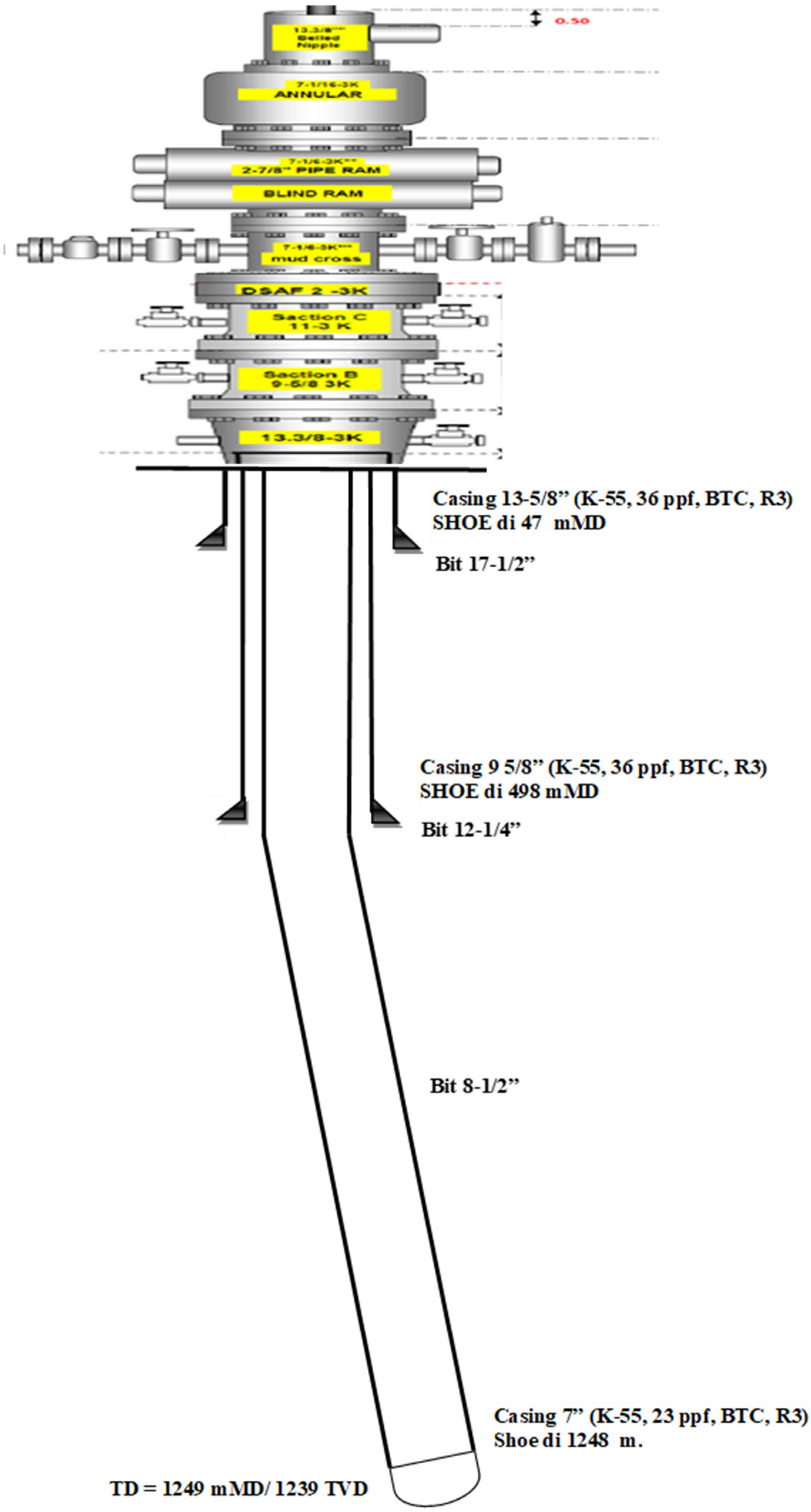

Figure 3. Well profile ZAZ-24

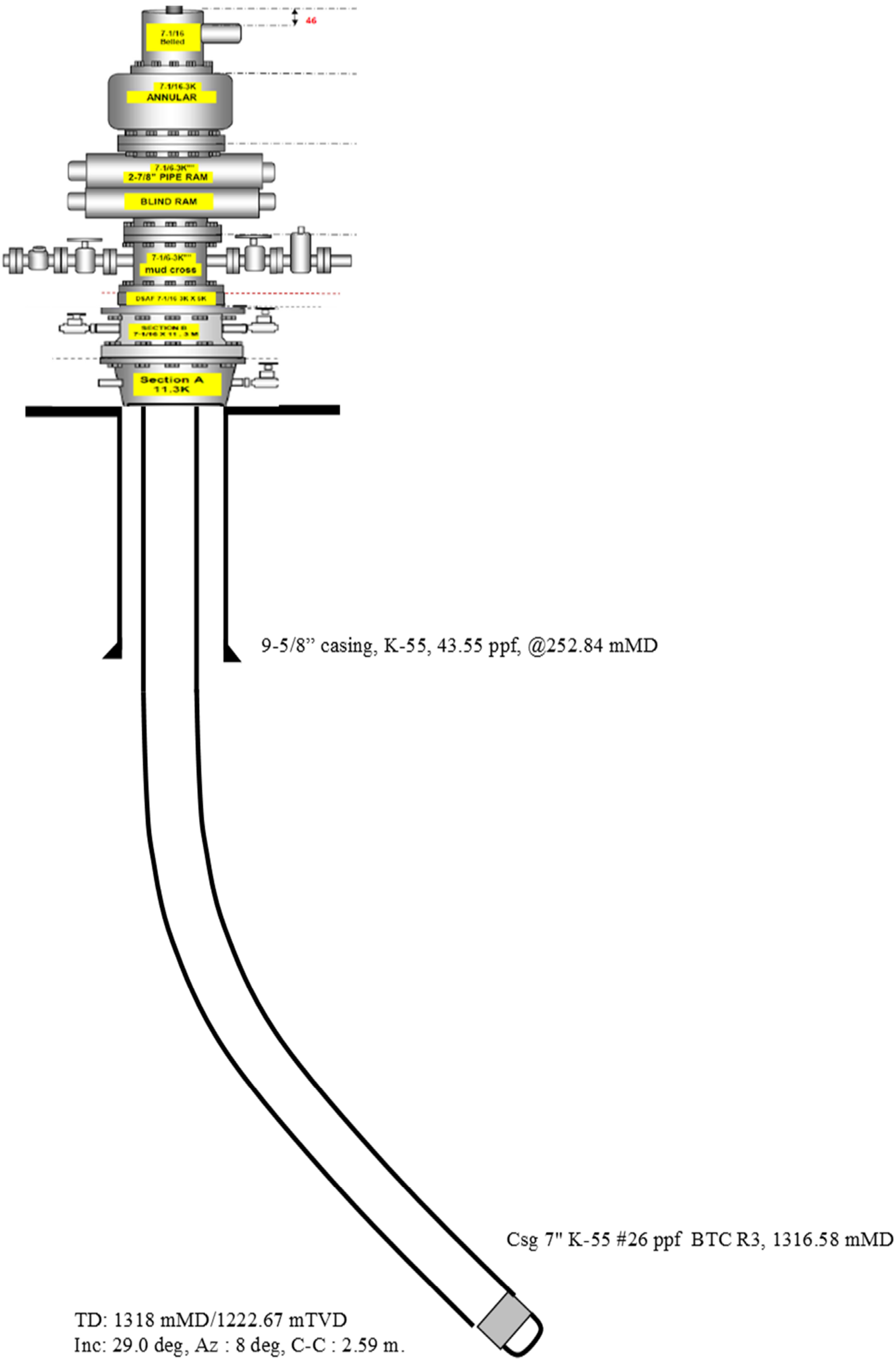

Figure 4. Well profile of ZAZ-32.

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Data of casing and bit

The casing data analyzed in this study included interval, grade, and pounder data used in the well. For ZAZ-24, three casing interval were required, while for OPW-24, two casing interval data points were needed (Table 2). The bit used was a Polycrystalline Diamond Cutter (PDC). ZAZ-24 used two bit sizes: 12-1/4 inches and 8-1/2 inches, while ZAZ-32 used a single bit size of 8-1/2 inches.

RESULT AND DISCUSSION

The evaluation of drilling well costs was conducted to analyze the factors influencing the reduction of drilling costs in ZAZ Field wells, comparing Three Phase Wells (TPW) and One Phase Wells (OPW). The analysis focused on assessing the impact of drilling cost components on the overall cost and examining the cumulative percentage of each component's contribution to total drilling costs for the ZAZ-24 and ZAZ-32 wells. The results of the drilling cost evaluation for each component in ZAZ-24 and ZAZ-32 are presented in Table 3 and Figure 7.

Drilling costs for ZAZ-24 and ZAZ-32 were evaluated and analyzed, revealing that 16 drilling cost components significantly influenced the high cost of drilling wells in the ZAZ Field. The components of the drilling costs for both ZAZ-24 and ZAZ-32 wells are shown in Table 4.

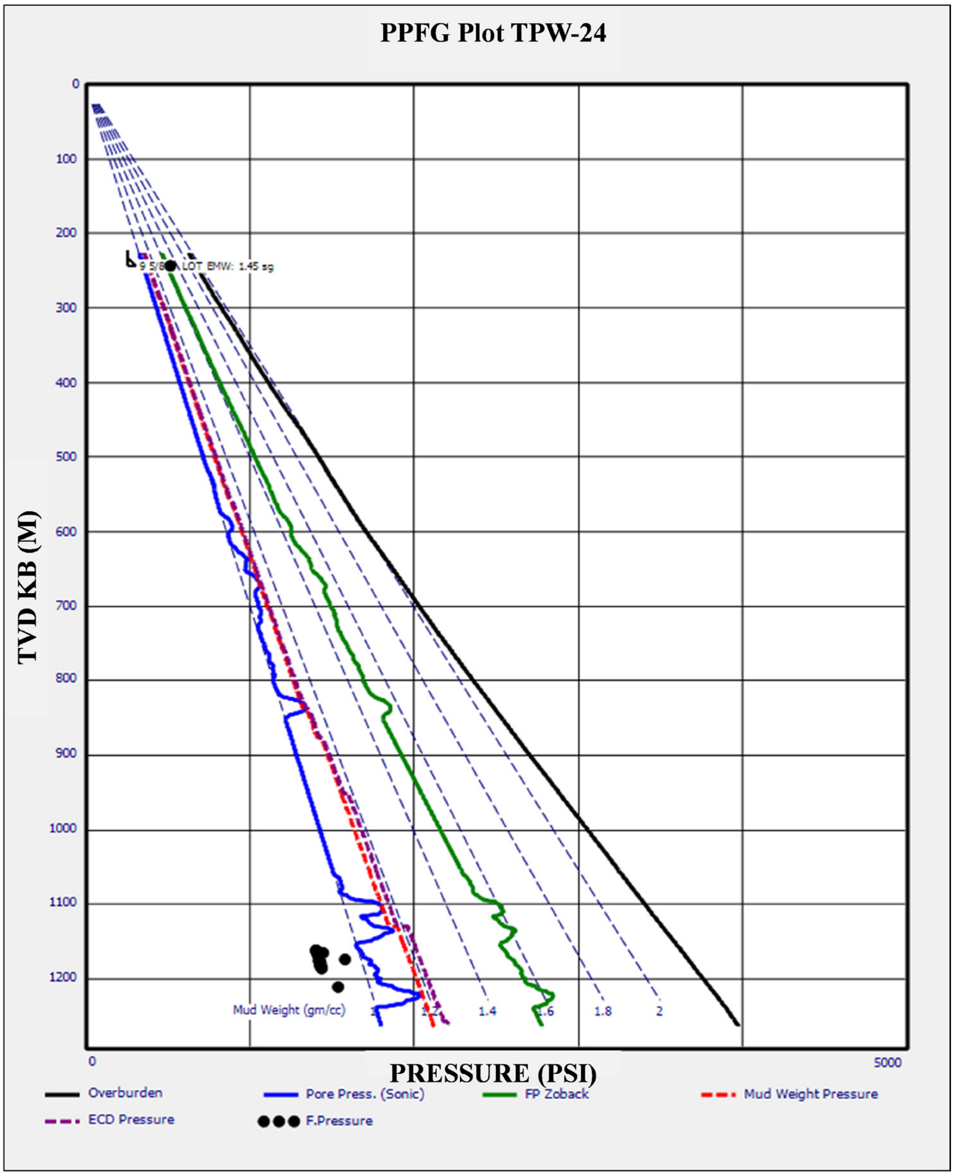

Figure 5. Pore Pressure Fracture Gradient (PPFG) of ZAZ-24.

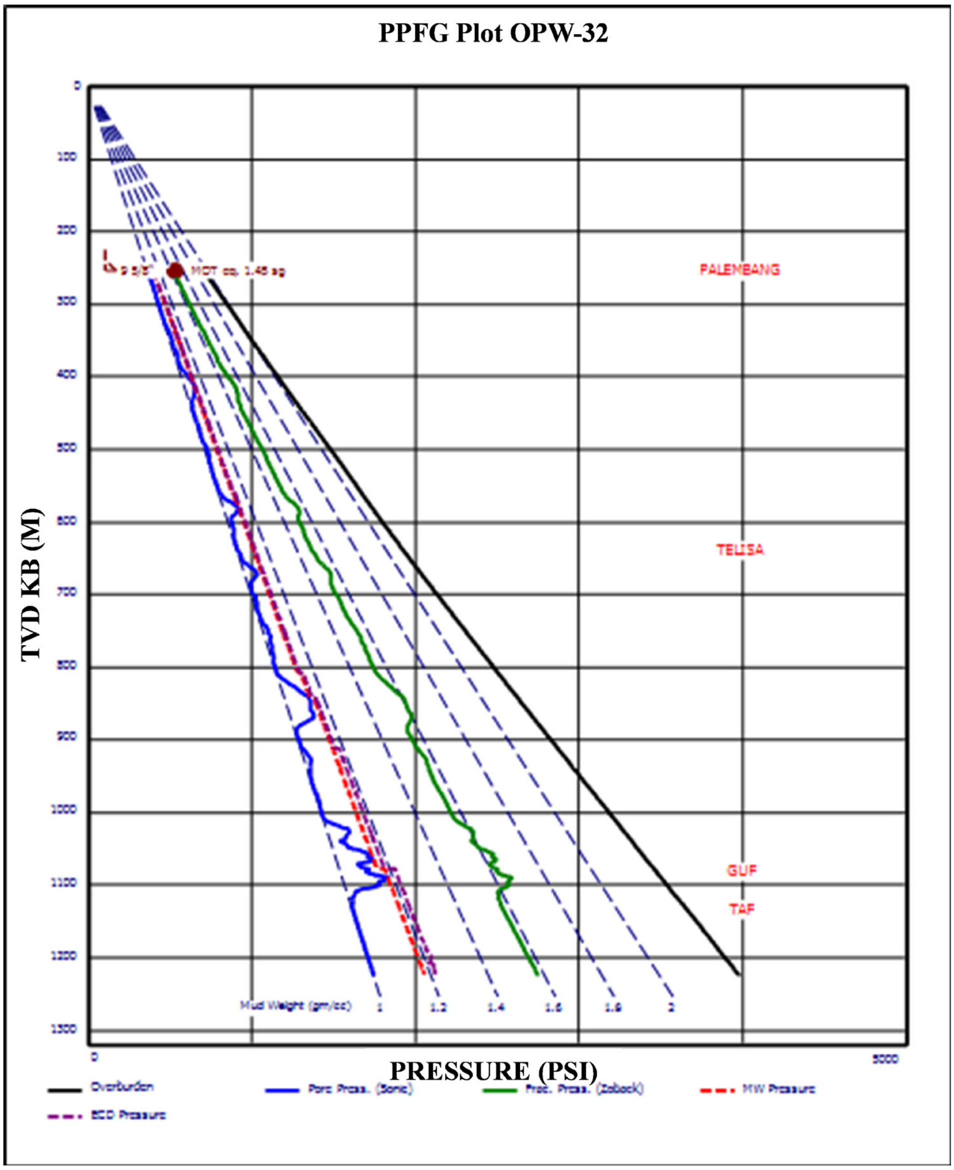

Figure 6. Pore Pressure Fracture Gradient (PPFG) of ZAZ-32.

Table 2. Casing data for ZAZ-24 and ZAZ-32.

String	OD (inch)	Weight (ppf)	Grade	Connection	MD Interval (m)
ZAZ-24					
Conductor Casing	13 3/8	54.5	K-55	BTC	0 - 50
Surface Casing	9 5/8	36.0	K-55	BTC	0 – 500
Production Casing	7	23.0	K-55	BTC	0 -1241
ZAZ-32					
Conductor Casing	9 5/8	36.0	K-55	BTC	0 - 252
Production Casing	7	23.0	K-55	BTC	0 - 1316

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Table 3. Drilling costs well of ZAZ Field

No	Component of Drilling Cost	ZAZ-24			ZAZ-32		
		Value ($)	% Relative	% Cumulative	Value ($)	% Relative	% Cumulative
1	Drilling Cost	1,146,567	50	50	1,041,484	50	50
2	Wellsite and Road Preparation	946,996	41	91	832,791	40	89
3	Non-Drilling Cost	202,073	9	100	225,042	11	100
	Total	2,295,636	100		2,099,317	100	

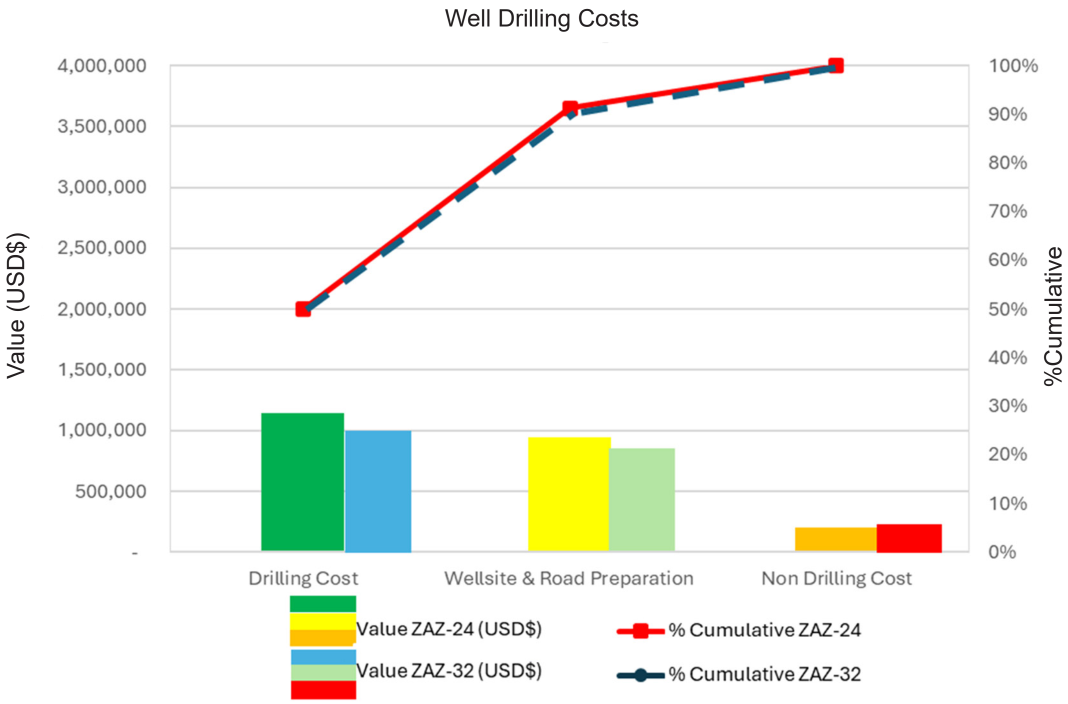

Figure 7. Comparison of Drilling well cost of ZAZ-24 and ZAZ-32.

The standard drilling design in the ZAZ Field is the TPW. However, to reduce drilling costs, an OPW design was implemented. The results of the analysis comparing the Three Phase Well (TPW) design to the ZAZ-32 well can be seen in Figure 8. In the ZAZ-32 well diagram, the surface casing, which was included in the ZAZ-24 design, was eliminated. Drilling operations were conducted up to the final depth of the well using only one casing trajectory.

A comparative analysis of the one-phase and Three Phase Well designs was conducted for the ZAZ-32 well to evaluate the economic implications of each design. This analysis aimed to determine the extent to which drilling costs could be reduced by switching from the TPW design to the OPW method in the ZAZ Field.

The conductor casing is the first casing installed from the surface to a depth of 252 mMD to seal the unconsolidated formation at shallow depths. It is also used to install the wellhead and as a BOP seat during drilling operations. In the OPW method, the conductor casing must be installed as deep as possible to prevent formation rupture caused by high mud flow rates. The production casing in the OPW method isolates the production interval from other formations. It is installed from the surface to the final depth of 1316 mMD.

Table 4. Components of drilling costs for ZAZ-24 and ZAZ-32 Wells.

No	Description	Z0041Z-24		ZAZ-32	
		Total Cost, $	% Cost	Total Cost, $	% Cost
1	Casing and Accessories	75,431	6.6	61,862	5.9
2	Tubing	20,321	1.8	21,580	2.1
3	Well Equipment - Surface	77,676	6.8	70,457	6.8
4	Well Equipment - Sub Surface	6,175	0.5	3,087	0.3
5	Service Lines and Communications	3,977	0.3	4,117	0.4
6	Rig	356,125	31.1	393,342	37.8
7	Mud	74,272	6.5	73,459	7.1
8	Bits	33,376	2.9	8,026	0.8
9	Equipment Rental	5,746	0.5	6,048	0.6
10	Directional Drilling and Surveys	92,566	8.1	49,725	4.8
11	Casing Instalation	0	0	24,017	2.3
12	Cementing job	116,279	10.1	119,801	11.5
13	Formation Evaluation	227,245	19.8	133,102	12.8
14	Cement Evaluation	8,381	0.7	28,841	2.8
15	Perforating And Wireline Services	14,732	1.3	14,528	1.4
16	Stimulation Treatment	34,264	3.0	29,492	2.8
	Total	1,146,567	100.0	1,041,484	100.0

The One Phase Well design for ZAZ-32 has an open hole length of 8-1/2 inches, which is longer than the Three Phase Well design at the same depth. Casing evaluation for ZAZ-32 was carried out by analyzing stress check, torque and drag (hookload) using a simulator program. Stress check analysis is used to assess the feasibility of using 7 inch production casing (Figure 9), with a K-55 casing grade and a 26 ppf pounder, installed in the ZAZ-32 well to a depth of 1316 mMD. From the torque and drag analysis on the ZAZ-32 well using both one-phase and Three Phase Well designs, the findings indicate that maximum torque OPW is 12,518.1 ft-lbf (Figure 10) and TPW is 12,451.6 ft-lbf (Figure 11). The torque for the One Phase Well (OPW) design is slightly higher than the Three Phase Well (TPW) design. This increased torque suggests a greater mechanical load on the drill string, leading to a higher risk of mechanical failure or operational issues during drilling in the One Phase Well (OPW). The drag value for the OPW is 89.1 klbs (Figure 12) and the TPW is 92 klbs (Figure 13), indicating that the drag is slightly lower for the one-phase design. However, despite this lower drag, the risk associated with the One Phase Well (OPW) design is still higher, particularly during the casing-running process, as the torque's influence may outweigh the marginally lower drag in terms of operational safety. The higher torque in the one-phase design increases the potential for operational challenges, such as higher stresses on the drill string and equipment wear. During the casing process, the slight reduction in drag for the One Phase Well (OPW) design may not be sufficient to mitigate the increased risks associated with higher torque.

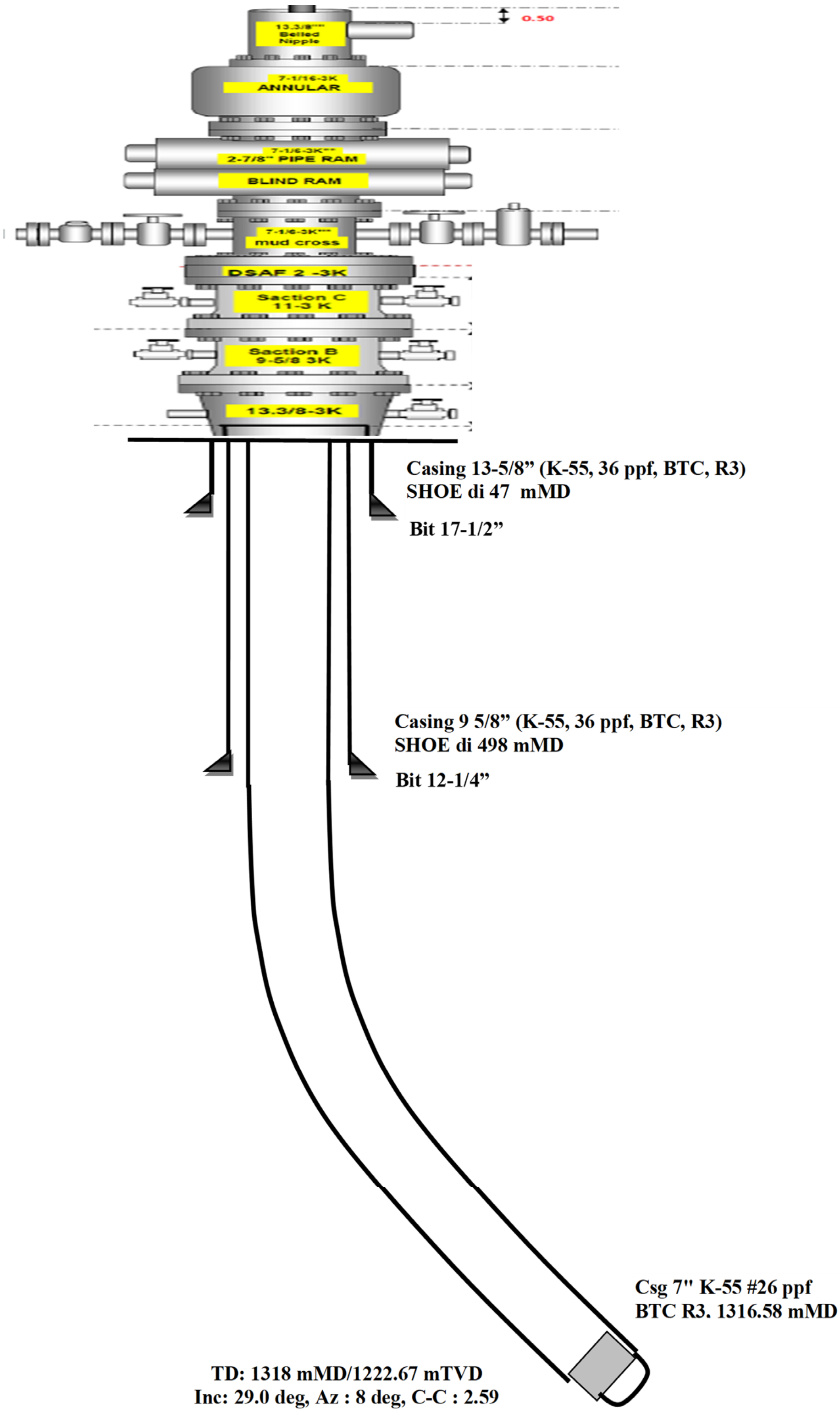

Figure 8. Three phase well design on ZAZ-32.

While the one-phase design has a slightly lower drag, its higher torque value increases the operational risk compared to Three Phase Well (TPW) design. Therefore, careful consideration of the torque and drag trade-offs is essential. The Three Phase Well (TPW) design appears to provide a better balance of lower operational risk, particularly for scenarios where torque presents a significant challenge. The drilling time for the ZAZ-32 well using the One Phase Well (OPW) method is 7.4 days to a depth of 1316 mMD. By using the drilling time data for the ZAZ-24 well, the drilling time for the Three Phase Well (TPW) method on the ZAZ-32 well is calculated to be 11.3 days.

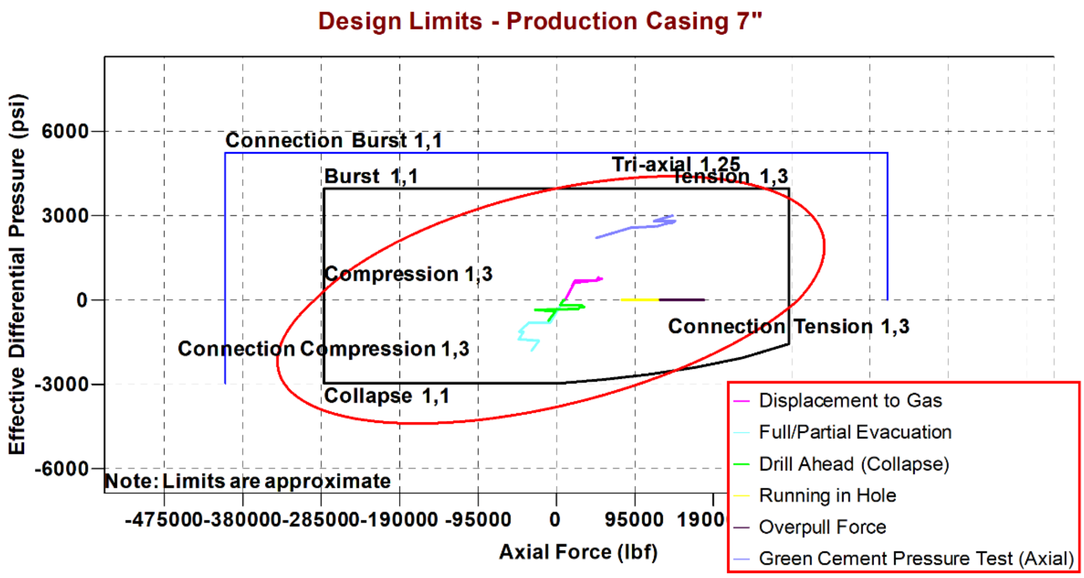

Figure 9. . Stress check casing 7” for ZAZ-32 well.

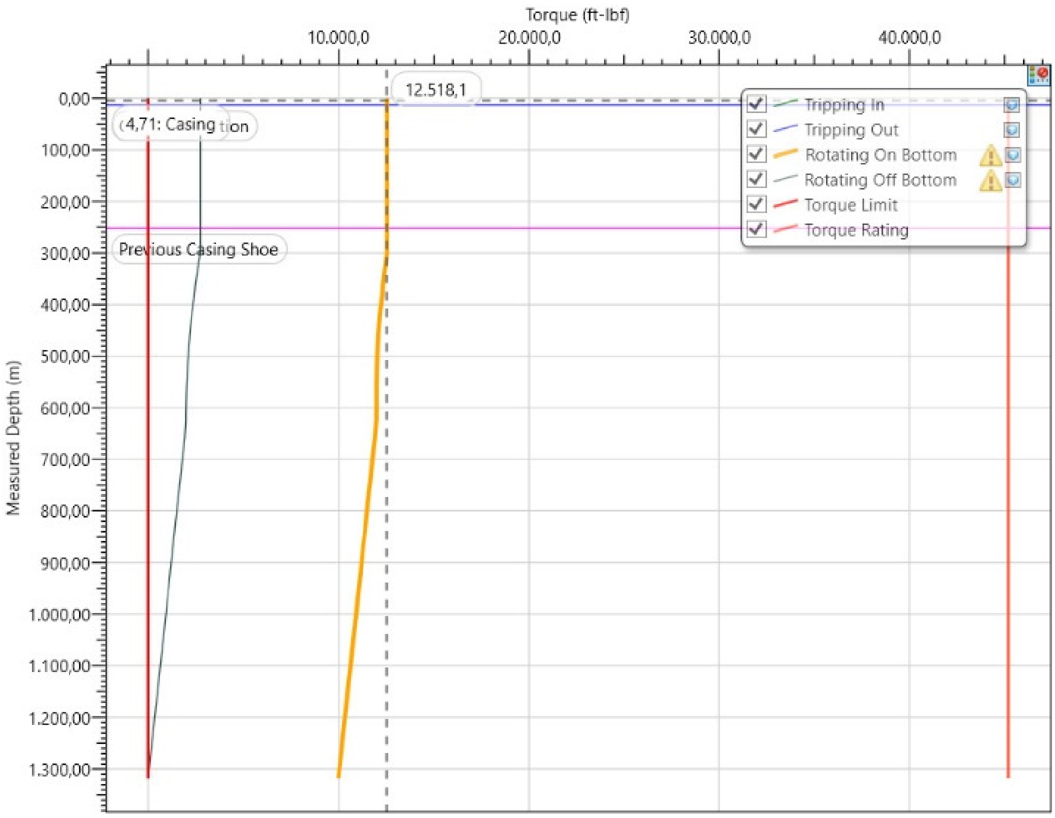

Figure 10. . Torque casing 7” for ZAZ-32 well.

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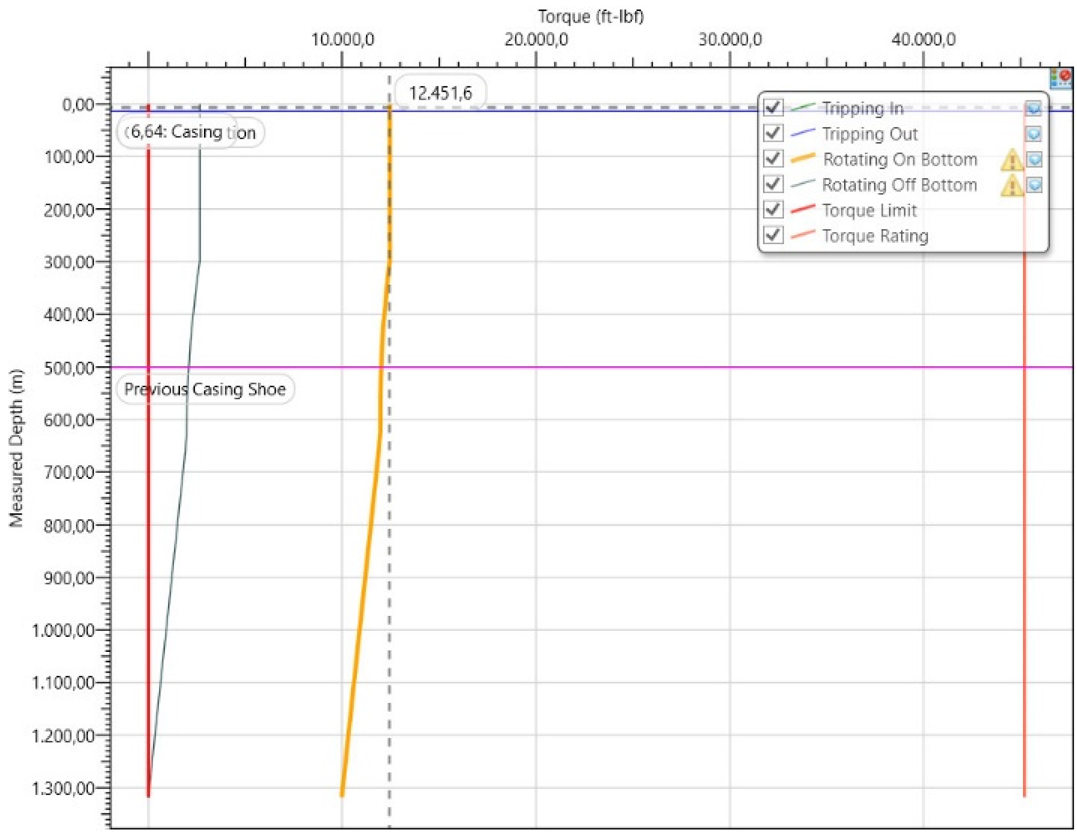

Figure 11. Torque casing 7" for ZAZ-32 well with TPW design.

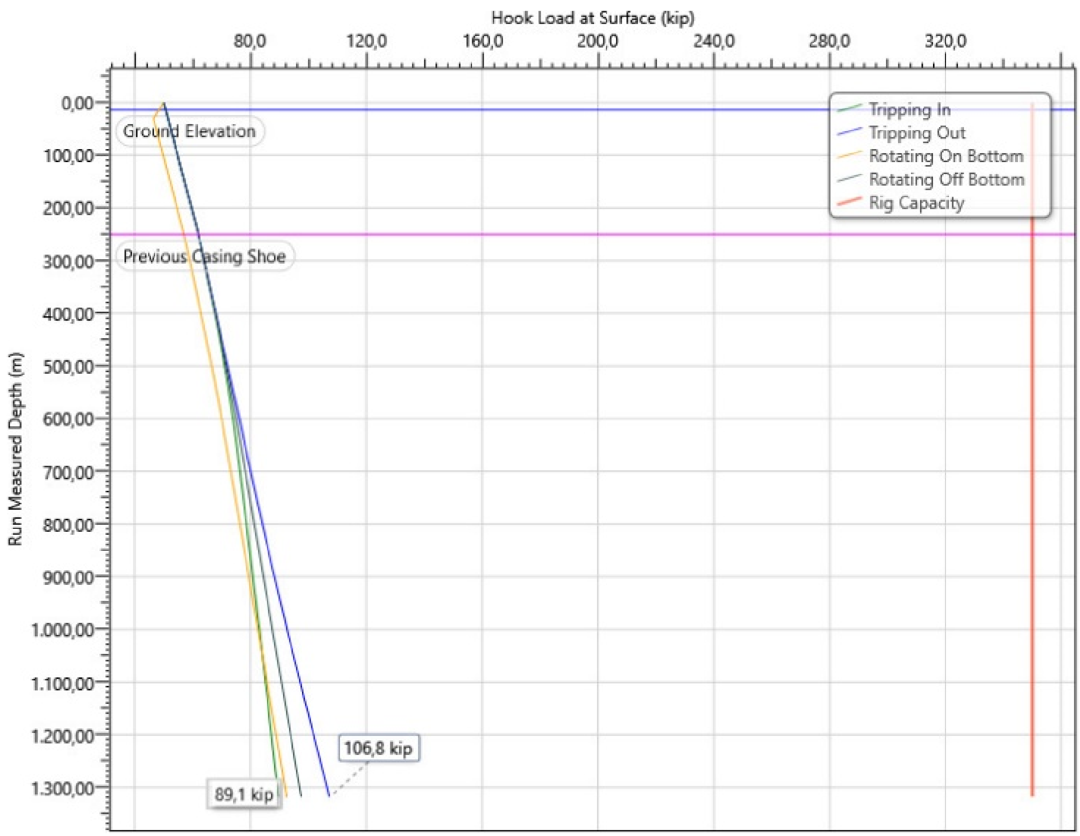

Figure 12. Drag casing 7" ZAZ-32

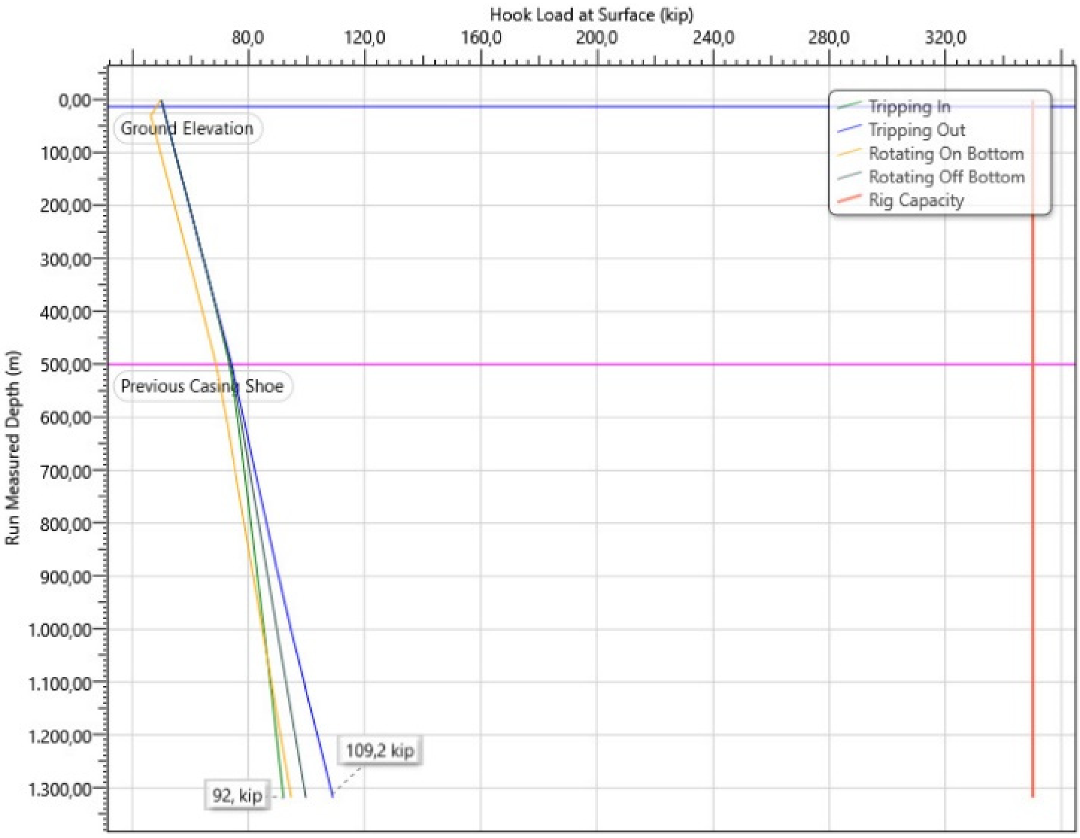

Figure 13. Drag casing 7" ZAZ-32 with TPW design

The drilling stages of the wells are plotted so that the length of drilling time can be analyzed. The plot's results are evaluated against the drilling time of the TPW and OPW wells. Table 5 and Figure 14 show the drilling time and drilling stages of the ZAZ-24 well and the ZAZ-32 well, as well as the Three Phase Well (TPW) design of the ZAZ-32 well. Analysis of the drilling cost components for the ZAZ-32 well using both the one-phase and Three Phase Well (TPW) methods indicates a difference in drilling costs. Drilling the ZAZ-32 well using the OPW method requires a total cost of USD 470,616.05, whereas drilling with the TPW method costs USD 539,249.58. The difference in drilling costs is 68,633.53 USD, meaning the OPW method can reduce drilling costs in the ZAZ Field. Drilling cost evaluation is conducted by analyzing cost components, including casing costs, mud, cement, rig rental, wellhead, and bit. Table 6 shows the casing and accessories used, the quantities, and the prices for each well design.

Table 5. Well drilling dtages at ZAZ field

Interval	Drilling Sequence	Time, (Day)	Cumulative (Day)	Depth (m)
	ZAZ-24			
A	12,25" OH to Casing Point, Circulation, Trip, POOH and L/D BHA	2.60	2.60	550
B	RIH and 9.5/8" Casing Cementing job, WOC, N/U WellHead, N/U BOP and Pressure Test	2.50	5.10	550
C	Drilling 8,5" OH to Casing Point, Circulation, Trip, POOH and L/D BHA	2.87	9.10	1249
D	Open Hole Logging	2.00	11.10	1249

Table 5. Well drilling dtages at ZAZ field (continued)

Interval	Drilling Sequence	Time, (Day)	Cumulative (Day)	Depth (m)
	ZAZ-32			
A1	Drilling 8,5" OH to Casing Point, Circulation, Trip, POOH and L/D BHA	4.00	4.00	1316
B1	Open Hole Logging	3.40	7.40	1316
	ZAZ-32 with TPW Method			
A2	12,25" OH to Casing Point, Circulation, Trip, POOH and L/D BHA	2.60	2.60	550
B2	RIH and 9.5/8" Casing Cementing job, WOC, N/U WellHead, N/U BOP and Pressure Test	2.50	5.10	550
C2	Drilling 8,5" OH to Casing Point, Circulation, Trip, POOH and L/D BHA	2.87	7.97	1316
D2	Open Hole Logging	3.40	11.37	1316

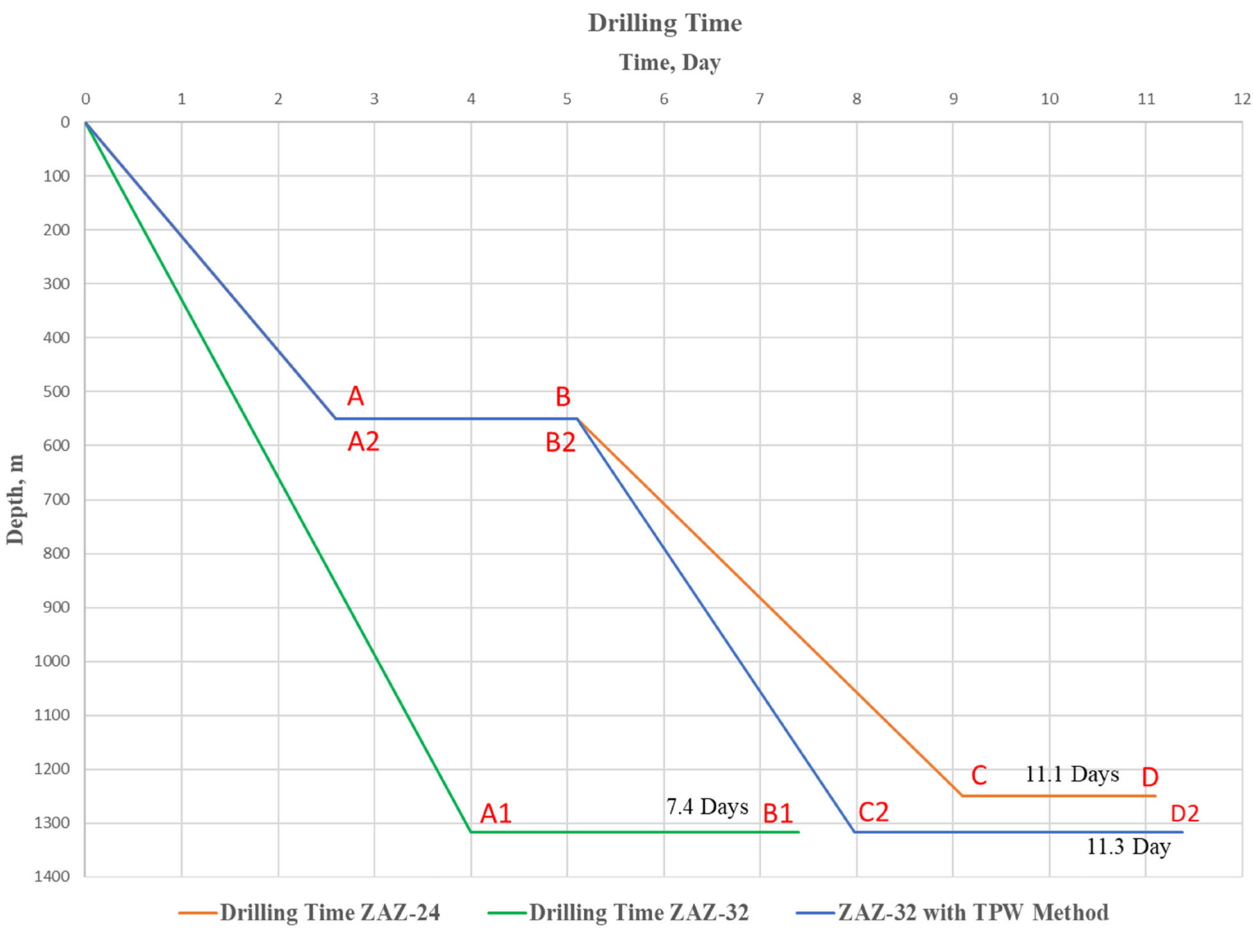

Figure 14. Drilling time of ZAZ-24 and ZAZ-32

Tabel 6. Casing costs of TPW and OPW design

No	Decription	Quantity	Price $
	ZAZ-24		
1	Casing 13 3/8 in, K55, 54,5 PPF, BTC, R3	4	4,196.40
2	Casing 9 5/8 in, K55, 36,0 PPF, BTC, R3	41	27,569.32
3	Casing 7 in, K55, 23,0 PPF, BTC, R3	104	40,984.26
4	Float Collar 9 5/8 in, N80, BTC, 36-43.5	1	718.50
5	Float Collar 7 in, N80, BTC, 20-26	1	355.76
6	Float Shoe 13 3/8 in, K55, BTC, 54.5-68	1	753.94
7	Float Shoe 9 5/8 in, K55, BTC, 36-47	1	454.74
8	Float Shoe 7 in, K55, BTC, 20-26	1	398.51
	Total Price		75,431.43
	ZAZ-32		
1	Casing 9 5/8 in, K55, 43.5 PPF, BTC, R3	21	14,120.87
2	Casing 7 in, K55, 26,0 PPF, BTC, R3	110	43,348.73
3	Float Collar 7 in, N80, BTC, 20-26	1	355.76
4	Float Shoe 9 5/8 in, K55, BTC, 40-47	1	454.74
5	Reamer Shoe 7 in, K55, BTC, 20-26	1	3,581.76
	Total Price		61,861.86
	ZAZ-32 Three Phase Version		
1	Casing 13 3/8 in, K55, 54,5 PPF, BTC, R3	4	4,196.40
2	Casing 9 5/8 in, K55, 36,0 PPF, BTC, R3	41	27,569.32
3	Casing 7 in, K55, 23,0 PPF, BTC, R3	110	43,348.73
4	Float Collar 9 5/8 in, N80, BTC, 36-43.5	1	718.50
5	Float Collar 7 in, N80, BTC, 20-26	1	355.76
6	Float Shoe 13 3/8 in, K55, BTC, 54.5-68	1	753.94
7	Float Shoe 9 5/8 in, K55, BTC, 36-47	1	454.74
8	Float Shoe 7 in, K55, BTC, 20-26	1	398.51
	Total Price		77,795.91

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Table 7. Estimate of mud volume

Interval	Unit	Conductor	Surface	Production
ZAZ-24				
Mud Weight	SG	1.05	1.05-1.15	1.15-1.17
Hole Size	inch	17 1/2	12 1/4	8 1/2
Casing shoe size	inch	-	12,615	8,921
Shoe Depth	meter	0	50	500
Total Depth	meter	50	500	1249
OH Length	meter	50	450	749
OH Volume	bbl	49	215	172
Casing Volume	bbl	0	25,361	126,829
Hole Volume	bbl	49	241	299
Total Hole Volume	bbl		589	
ZAZ-32				
Mud Weight	SG	1.05-1.10		1.10-1.20
Hole Size	inch	12 1/4		8 ½
Casing shoe size	inch	-		8.921
Shoe Depth	meter	0		252.84
Total Depth	meter	252,84		1318
OH Length	meter	253		1065
OH Volume	bbl	121		245
Casing Volume	bbl			64
Hole Volume	bbl	121		309
Total Hole Volume	bbl		430	
ZAZ-32 with Three Phase Well Method				
Mud Weight	SG	1,05	1.05-1.15	1.15-1.20
Hole Size	inch	17 1/2	12 1/4	8 1/2
Casing shoe size	inch	-	12.615	8.921
Shoe Depth	meter	0	50	500
Total Depth	meter	50	500	1318
OH Length	meter	50	450	818
OH Volume	bbl	49	215	188
Casing Volume	bbl	0	25	127
Hole Volume	bbl	49	241	315
Total Hole Volume	bbl		605	

To determine the cost of drilling mud and cement slurry used in the one-phase and Three Phase Well (TPW) methods, calculations were made for the volume of drilling mud used in both the ZAZ-24 and ZAZ-32 wells. The mud volume from each well was calculated to estimate the mud cost per barrel. The results of these calculations for drilling mud costs are shown in Table 7 and Table 8. The volume of cement is calculated in Table 9 and Table 10. The cementing cost for the ZAZ-32 well using the one-phase method is derived from the total cement volume of 150 bbl and a cement cost of 119,801.15 USD, resulting in a cost of 799.45 USD per bbl. Using the ZAZ-24 cement cost per barrel, the cost of cementing the ZAZ-32 well using the three-phase method (with a total cement volume of 223 bbl) is 119,220.26 USD, yielding a cost of 534.62 USD per bbl.

The cost of the wellhead is shown in Table 11. The rig rental cost for the ZAZ-32 well using the one-phase method is calculated by multiplying the drilling time by the rig rental price per day, resulting in a rig rental cost of 113,960 USD per day. The drilling time for the ZAZ-32 well using the three-phase method is 11.3 days, resulting in a total rig rental cost of 176,098 USD.

Table 8. Evaluation of drilling mud costs

Well Type	Total Volume, bbl	Total Cost, $	Cost, $/bbl
ZAZ-24	589	74.271,62	126,16
ZAZ-32	430	73.458,57	170,69
ZAZ-32 (TPW)	605	76.276,23	126,16

Tabel 9. . Estimation of cement volume.

Interval	Unit	Conductor	Surface	Production
ZAZ-24				
Hole Size	inch	17 1/2	12 1/4	8 1/2
Casing Size (OD)	inch	13 3/8	9 5/8	7
Casing Size (ID)	inch	12,615	8,921	-
Starting Depth	meter	0	50	500
Ending Depth	meter	50	500	1249
Section Length	meter	50	450	749
Casing to OH	bbl	20	82	56
Casing to Casing	bbl	-	11	49
Volume Each Section	bbl	20	93	104
Total Volume	bbl		217	
ZAZ-32				
Hole Size	inch	12 1/4		8 1/2
Casing Size (OD)	inch	9 5/8		7
Casing Size (ID)	inch	8,921		-
Starting Depth	meter	0		253
Ending Depth	meter	253		1318

Tabel 9. . Estimation of cement volume (continued)

Interval	Unit	Conductor	Surface	Production
ZAZ-32				
Section Length	meter	253		1065
Casing to OH	bbl	46		79
Casing to Casing	bbl	-		25
Volume Each Section	bbl	46		104
Total Volume	bbl		150	
ZAZ-32 with TPW method				
Hole Size	inch	17 1/2	12 1/4	8 1/2
Casing Size (OD)	inch	13 3/8	9 5/8	7
Casing Size (ID)	inch	12,615	8,921	-
Starting Depth	m	0	50	500
Ending Depth	m	50	500	1318
Section Length	m	50	450	818
Casing to OH	bbl	20	82	61
Casing to Casing	bbl	-	11	49
Volume Each Section	bbl	20	93	109
Total Volume	bbl		223	

Table 10. Evaluation of drilling cement costs

Well Type	Total Volume, bbl	Total Cost, $	Cost, $/bbl
ZAZ-24	217	116.278,75	534,62
ZAZ-32	150	119.801,15	799,45
ZAZ-32 (TPW)	223	119.012,38	534,62

Table 11. Well head size, type and price

Section	Wellhead Size (inch)	Total Price ($)
ZAZ-24		
A	13-3/8 x 9-5/8	
B	9-5/8 x 7	77.676,30
C	7 x 2-7/8	
ZAZ-32		
A	9-5/8 x 7	70.924,62
B	7 x 2-7/8	

Table 12. Difference in drilling costs between OPW and TPW design

No	Description	ZAZ-32 (One Phase Well)		ZAZ-32 (Three Phase Well)		Difference	
		Total Cost ($)	% Cost	Total Cost ($)	% Cost	Total Cost ($)	% Cost
1	Casing and Accessories	61.861,86	13	77.795,91	14	-15.934,04	-20,5
2	Well Equipment - Surface	70.924,62	15	77.676,30	14	-6.751,68	-8,7
3	Mud	73.458,57	16	76.276,23	14	-2.817,67	-3,7
4	Bits	6.174,92	1	13.390,77	2	-7.215,84	-53,9
5	Casing Installation	24.434,93	5	0	0	24.434,93	100
6	Cementing Job and Accessories	119.801,15	25	119.012,38	22	788,78	0,7
7	Rig	113.960,00	24	175.098,00	32	-61.138,00	-34,9
Total		470.616,05	100	539.249,58	100	-68.633,53	-12,7

The wellhead for the ZAZ-32 consists of two types with a total cost of 70,924.62 USD, while the ZAZ-24 wellhead design consists of three types with a cost of 77,676.30 USD. The bit used for ZAZ-24 is PDC with two bit sizes: 12-1/4 inches priced at 7,216 USD and 8-1/2 inches priced at 6,175 USD. In contrast, ZAZ-32 uses only the 8-1/2-inch PDC bit, which costs 6,175 USD. The cost of the ZAZ-32 bit with the Three Phase Well (TPW) method is 13,391 USD.

An analysis of the drilling cost components for the ZAZ-24, ZAZ-32, and ZAZ-32 using the three-phase method shows a cost difference between the drilling methods. Drilling the ZAZ-32 well using the OPW method requires a total drilling cost of 470,616.05 USD, while drilling the ZAZ-24 well costs 539,249.58 USD. The difference in drilling.g costs is 68,633.53 USD, indicating that using the OPW method will reduce drilling costs in the ZAZ Field. Table 12 shows a detailed breakdown of the drilling cost differences for the ZAZ-32 well using both the OPW and TPW methods.

CONCLUSION

The use of the One Phase Well method is appropriate for addressing the problem of high drilling costs in the ZAZ Field, while ensuring safety, effectiveness, and efficiency. Drilling costs using the One Phase Well method can reduce casing costs by 20.5%, mud costs by 3.7%, rig rental costs by 34.9%, wellhead costs by 8.7%, and bit costs by 53.9%. However, cement costs increase by 0.7%, and there is an additional casing installation cost of $ 24,435. Despite this, the total drilling costs for the one-phase method are reduced by 12.7% compared to the Three Phase Well (TPW) method.

The drilling operation in the ZAZ Field for the ZAZ-24 well using the Three Phase Well (TPW) method has a drilling cost of $ 1,146,567, while the ZAZ-32 well using the one-phase method costs 1,041,484 USD. This shows that drilling with the three-phase method exceeds the budget by 105,083 USD compared to the one-phase method.

The drilling cost analysis identifies the cost components contributing to the total drilling cost of the ZAZ-24 and ZAZ-32 wells. The cost components that influence the two methods are: rig costs, with the highest contribution ranging from 31.1% to 37.8%; cementing jobs at 10.1% to 11.5%; mud costs at 6.5% to 7.1%; well equipment and surface costs at 6.8%; casing and accessories at 5.9% to 6.6%; and bit costs at 0.8% to 2.9%.

The implementation of the One Phase Well (OPW) method on the ZAZ-32 well can reduce drilling time, with the one-phase method completing the work 3.9 days faster than the three-phase method.

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GLOSSARY OF TERMS

Symbol	Definition	Unit
Az	Azimuth	degree
ID	Inside Diameter	inch
Inc	Inclination	degree
KOP	Kick of Point	meter
MD	Measured Depth	meter
OD	Outside Diamter	inch
TD	Total Depth	meter
TVD	True Vertical Depth	meter
TVDSS	True Vertical Depth Sub-Sea	meter
bbl	Barrel	
BHA	Bottom Hole Assembly	
BOP	Blow Out Preventer	
BTC	Buttress Thread Connection	
DDR	Daily Drilling Report	
HP	Horse Power	
L/D	Lay Down	
N/U	Nipple Up	
OH	Open Hole	
OPW	One Phase Well	
PDC	Polycrystalline Diamond Cutters	
POOH	Pulling of out hole	
PPF	Pound Per Feet	
PPFG	Pore Pressure Fracture Gradient	
RIH	Running In Hole	
TPW	Three Phase Well	

REFERENCES

Bahari, A., & Seyed, B. (2007) Drilling Cost Optimization in Iranian Khangiran Gas Field (SPE Paper No. 108246). Mexico. https://doi.org/10.2118/108246-MS.

El Bakly, O., Ali, K., & El Dawey. (2007). Optimized drilling cost per foot in KPC versus the increase of drilling tangible and intangible costs (Case study) (SPE/IADC Paper No. 108298). Egypt. https://doi.org/10.2118/108298-MS.

WYP, E. E., & Risna, R. (2010). Penelitian Desain Lumpur untuk Mengatasi Terjadinya Pengendapan oleh Material Lumpur maupun Formasi akibat Pengaruh Temperatur Tinggi dan Kontaminan Fluida Formasi. LEMBARAN PUBLIKASI MINYAK DAN GAS BUMI (LPMGB), 44(2), 171-184. https://doi.org/10.29017/LPMGB.44.2.162.

Halal, A.S., Warling, D.J., & R.R., Wagner. (1996). Minimum Cost Casing Design (SPE Paper No. 36448). Colorado. https://doi.org/10.2118/36448-MS.

Handoko, A.I., Bimastianto, P., Maulana, M.D., Agriawan, C., Brahmantio, R.A., Abidiy, I. & Setiawan, T. (2017). Shallow Light Architecture: A Viable and Cost-Effective Solution for Marginal Reserves in Tunu Shallow Development (SPE-186936-MS). Jakarta. https://doi.org/10.2118/186936-MS.

Hanif, I., Sayogyo, B., Riko, R., Hadistira, P., & Sari, K. (2021). One Phase Well (OPW): Unlock shallow reservoir efficiently and economically by eliminating surface casing (SPE Paper No. 205612-MS). PT Pertamina Mahakam. https://doi.org/10.2118/205612-MS.

Julikah, J., Sriwidjaya, S., Hadimuljono, J. S., & Panuju, P. (2015). Hydrocarbon Shale Potential in Talang Akar and Lahat Formations on South and Central Palembang Sub Basin. Scientific Contributions Oil and Gas, 38(3), 213-223. https://doi.org/10.29017/SCOG.38.3.549.

Julikah, J., Rahmat, G., Wicaksono, A. B., & Anwari, J. (2020). Shale Plays Characterization of the Talang Akar Formation in the Jambi Sub-Basin, South Sumatra Basin. Scientific Contributions Oil and Gas, 43(3), 99-114. https://doi.org/10.29017/SCOG.43.3.517.

Oumer, S., Taufiqurrachman, H., Perruchot, M., & Yunus, F. (2010). Well Design Specificities for Shallow Gas Production of Tunu Field, IADC/SPE 134957, Ho Chi Minh, Vietnam. https://doi.

org/10.2118/134957-MS.

Oumer, S., Widiwibowo, F., Yunus, F., & Choux, J.-C. (2012). Indonesia "Tunu 18 Days" project case history: Innovations and new technologies bringing well construction performance to unthinkable levels (IPTC Paper No. 14808). Bangkok. https://doi.org/10.2523/IPTC-14808-MS

Sayogyo, B., Hermawan, A., & Andoni, B. (2022). Delivering a one-phase well in under two days with a one-inch cutter PDC drill bit: A record-breaking performance in a mature field, drilling optimization case history (OTC Paper No. 31638-MS). Kuala Lumpur. https://doi.org/10.4043/31638-MS.

Wibowo, A. S., Ulpah, N., Ariel, G., Ismail, T., & Sobirin, M. (2022). Industrialization One Phase Well Perforation in Marginal Shallow Reservoir while Maintaining Proper Well Integrity Aspect: Successful Milestone in Tunu Field, Delta Mahakam, East Kalimantan., IATMI, Yogyakarta. https://journal.iatmi.or.id/index.php/ojs/article/download/295/301/895.

Wojtanowicz, A. K., State, L., Eric, U., & Maidla, E. (1987). Minimum-cost casing design for vertical and directional wells. Journal of Petroleum Technology, (SPE Paper No. 17107). https://doi.org/10.2118/14499-PA.

Shahin, M. (2018). Casing drilling resulted in slimmer hole design and significant cost savings in the WON Field in Egypt (SPE Paper No. 192608-MS). https://doi.org/10.2118/192608-MS.

Rahanjani, Y. E., & Nugraha, B. (2020). Real-Time Data Transmission and Visualization as a Powerful Technology to Reduce Non-Productive Time During Drilling Operations: Present Day Capabilities, Limitation, and Future Development. Scientific Contributions Oil and Gas, 43(3), 135-142. https://doi.org/10.29017/SCOG.43.3.515.