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The Optimized Analysis Method for Cost Saving and Efficiency Improvement of Shale Gas Drilling Engineering in Sichuan-Chongqing Region

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Abstract: Since the key factors of shale gas development are Estimated Ultimate Recovery (EUR) and single well engineering cost, keeping the single well engineering cost decreasing and benefit-increasing becomes one of the most effective measures to realize high-quality development of shale gas. The high-efficiency development model of shale gas can be summed up as "horizontal well platform + super large scale fracturing + industrialized operation + integrated management", and the main contents of the four aspects are analyzed. Three main closely-related problems of shale gas development in the Sichuan-Chongqing area are discussed: unscientific valuation methods of drilling engineering, unreasonable allocation of resources and insufficient incentive measures. The revolutionary cost-decreasing and benefit-increasing matching measures – "three unifications" – are therefore put forward: the unification of engineering valuation methods, the unification of resource allocation, and the unification of incentive measures; The strong policies supporting matching measures – "three guarantees" – are proposed: the guarantee of land use, the guarantee of resource sharing, and the guarantee of the gas price; The overall high-quality development objectives – "three promotions" – are expected: overall promotion of production efficiency, overall promotion of management level, and overall promotion of whole benefits.

Key words: Shale Gas Drilling in Sichuan-Chongqing Region; Cost saving and efficiency improving; Pricing method and standard; Standard well; Project cost

1 Introduction

The shale gas development in the Sichuan-Chongqing area has undergone three stages: evaluation and selection (2006—2009), pilot test (2009—2014), and demonstration zones construction (2014—2017). Changning-Weiyuan and Zhaotong blocks have been preliminarily constructed as demonstration zones at the national level for shale gas

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development. These zones have applied successful U.S. experience for shale gas development, including the multi-well production model with one platform and the vertically integrated production organization method, basically forming an integrated technology system to exploit shale gas efficiently and cleanly（Jun X, 2018; Li H et al., 2024; Li J et al., 2025）. The technology system comprises the geological evaluation, optimization of development plans, high efficiency of drilling horizontal wells, volume fracturing, factory operations, and efficient & clean exploitation.

Generally speaking, shale gas production was 108×108m3 in 2018 in China. This production approximately equals that of the U.S., with $118\times10^8m^3$ in 2000（Weihe H et al., 2019; Weihe H & Hai L, 2019）. Large-scale development of shale gas is still at the beginning stage in China, and there still exist many management and technical problems, such as low practicability of shale gas resources, the lack of key/core technologies and systems, huge difficulty in environmental protection, incomplete construction of supporting pipeline networks and high development costs. The development management model for shale gas is still being explored（Yongsheng M ey al., 2018; Zhengguang L, 2016; Caineng Z et al., 2016; Caineng Z et al., 2015; Dazhong D et al., 2016）. In terms of drilling management, as large-scale production meets the trend, we adopt an economic mechanism design theory to achieve the general objective of maximizing the overall benefits. The analyses show that shale gas drilling in the Sichuan-Chongqing area mainly faces challenges like unscientific pricing methods, insufficient incentive measures, and unreasonable allocation of resources（Li J et al., 2025）, among which the first problem is most prominent for drilling investment management and its two unscientific aspects are shown as follows:

(1) No applicable pricing standards. In Sichuan-Chongqing region, there are currently three types of pricing standards concerning drilling engineering adopted by CNPC: (a) *Budget Quota Related to Drilling System Engineering for Sichuan Oil and Gas Field (Trial version)* issued by the Group Corporation in 2003; (b) *Interim Pricing Standards for Drilling System Engineering, Controlling Prices Concerning Technical Services for Special Operations Related to Downhole Drilling, and Controlling Prices for Unpriced Materials and Tools Concerning Drilling System Engineering* issued by PetroChina Southwest Oil and Gas Field Company; (c) the internal settlement standards formulated by Chuanqing Drilling Company for shale gas projects at different blocks, such as Weiyuan, Changning, Zhaotong, etc（Li J et al., 2025）. There are no suitable pricing standards for drilling investment in shale gas development because of the particularities of drilling engineering, such as industrialization operations and large-scale fracturing in long horizontal sections.

(2) Various pricing methods. Pricing methods of different construction companies can be summarized into three types in terms of the accounts regarding drilling financial costs, the drilling service contracts, and the drilling quota established in 2003. Some companies made investment estimates with reference to a 50% discount on the drilling quotas published in 2003. Some, however, based on different types of service teams, use the accounts related to financial costs to deconstruct the drilling investment, so as to account for the significant differences between the drilling project estimate (and budget) and practical costs, as well as the prominent contradictions between party A and party B.

According to the special planning requirements made by CNPC for shale gas development in the decade of 2021—2030, it needs to establish the drilling investment reference indicators for the working conditions in five blocks, three types of burial depth, and four kinds of horizontal section length. The indicators are applied to the investment calculation for development wells. The five blocks include Zhaotong, Changning, Weiyuan, Western Chongqing, and Luzhou. Three types of burial depth are 3,500m, 3,500-4,000m, and 4,000-4,500m. Four kinds of horizontal section length involve 1,500m, 2,000m, 2,500m, and 3,000m. Zhaotong, Changning and Weiyuan blocks have just developed shale gas with a buried depth of less than 3,500m; however, two blocks in Luzhou and Western Chongqing have not yet been developed. Given the limited data available currently, it difficultn't easy to scientifically and reasonably estimate the drilling investment for shale gas in the above-mentioned working conditions in 2021-2030. Meanwhile, when preparing for the medium and long-term plans for shale gas development, the application of existing investment measurement methods will make it possible for inaccurate economic evaluation results, which certainly affects scientific investment decisions and even leads to major decision errors. Based on the integrated development of shale gas, it is, therefore, urgent to study and establish a set of optimization analysis methods for drilling investment (see Fig. 1).

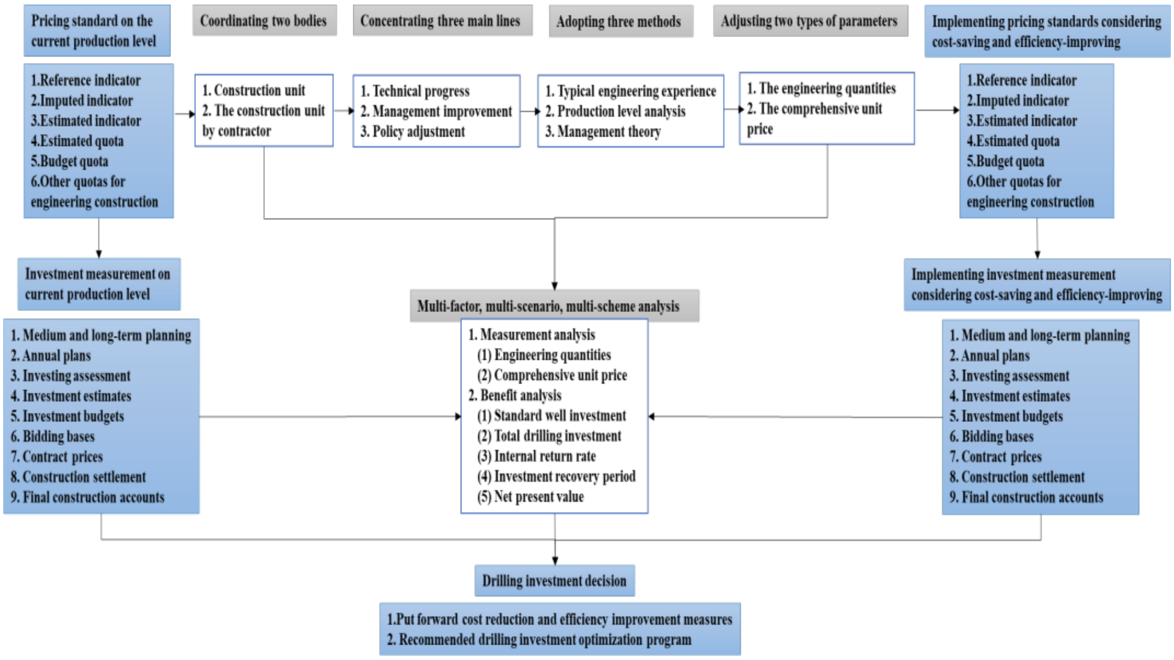

Figure 1 Pricing standard system for drilling engineering

2 Pricing methods and standards for the entire drilling process

As regards the three problems in drilling management for shale gas development in the Sichuan-Chongqing area, supporting measures, including three unified methods, are necessarily proposed and comprehensively implemented for the integrated development of shale gas, so as to reduce the costs and improve efficiency concerning drilling operations. The three unified methods consist of unified pricing methods, unified incentive measures, and unified resource allocation mechanisms, and the key content can be summarized as the combination of integrated pricing methods and management of standard wells. Furthermore, the supporting measures lay the groundwork for constituting a complete set of optimization analysis methods associated with drilling investment.

2.1 Integrated pricing methods

The pricing methods for drilling engineering are involved with the pricing work in each phase concerning drilling engineering projects from the beginning of decision-making to the construction completion. The integrated pricing methods develop a pricing method system for drilling engineering that meets the management needs of the entire construction process for oil and gas exploration and development projects. The pricing method system for construction companies comprises many aspects, such as the medium and long-term planning, annual plans, investment assessment, investment estimates, investment budgets, bidding bases, contract prices, construction settlement, and final construction accounts. For service companies, the system includes cost budget, bid quotation, contract price, and construction settlement.

The integrated pricing method requires developing a unified and standardized pricing standard system for the entire drilling process, which includes the calculation rules for the drilling quantities list and the composition of items in the drilling project cost.

(1) Basic concepts of pricing standards for construction companies

The reference indicator is a comprehensive average investment standard for drilling engineering in a certain oil and gas area. The reference indicator is mainly used to work out the drilling investment in the medium and long-term planning and in the pre-feasibility study (project proposal) for oil and gas exploration and development projects.

The imputed indicator is a comprehensive average cost standard for the same type of drilling projects in a certain oil and gas area. The imputed indicator is mainly used to draw up the drilling engineering impute and the investment framework of the annual drilling plan during the feasibility study of oil and gas exploration and development projects. Moreover, the imputed indicator lays the foundation for the reference indicator.

The estimated indicator is a standard for all engineering costs to invest in a standard well in a certain oil and gas area. The main role of the estimated indicator is listed in section 2.2, "standard well management". In addition, the estimated indicator is the basis for laying down the imputed indicator.

The estimated quota is a consumption standard for the overall drilling quantities to invest in a standard well in a certain oil and gas area under certain organization methods and conditions for production. As a comprehensive consumption quota used to establish the estimates and budgets for drilling projects, the estimated quota is the basis for laying down the estimated indicator, and also provides a quantitative standard for service companies to optimize the drilling quantities and save investment.

The budget quota refers to a cost standard for measurement units to evaluate the investment, including labor, equipment, materials and other items in drilling projects. As a kind of comprehensive unit price, it consists of three types of costs, that is, direct, indirect, and profits. The budget quota for drilling engineering also embraces three types of quota, namely, pre-drilling, drilling, and completion. Apart from being a kind of comprehensive pricing quota mainly used to work out drilling budgets and estimates, the budget quota is also the basis for establishing the estimated indicator, one of the main bases for laying down the bidding base, determining the contract price, and implementing the project settlement, as well as the basis for service companies to analyze the cost reduction and efficiency improving measures.

entities. Non-drilling entities consume other quotas for engineering construction and are closely related to the drilling cost standards, including construction management, engineering design, land use, environmental protection management, engineering insurance, reserve costs, loan interest, value-added tax, and other related costs. Other quotas related to engineering construction are indispensable cost standards for laying down the inputs, estimates, and budgets regarding drilling engineering and are also one of the bases for the estimated indicators.

(2) The preparation process of drilling pricing standards for construction companies

Fig. 2 shows the basic preparation process of the drilling pricing standards for construction companies. The drafting of drilling pricing standards generally includes four parts: drilling productivity level analysis, quotas preparation (budget quota, estimate quota, other quotas for engineering construction), indicators preparation (estimated indicators, imputed indicators, reference indicators), and pricing standard level analysis. The preparation process of pricing standards needs to be adjusted repeatedly to ensure that the project is scientifically set up with a reasonable quota value and convenient usability, and is generally at an advanced level.

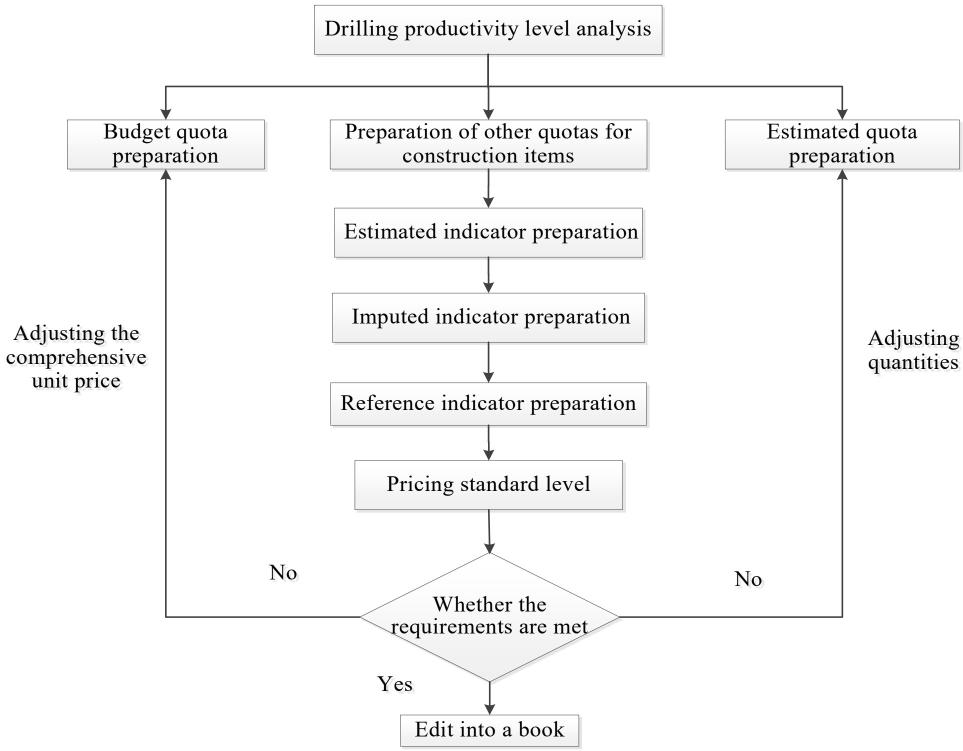

Figure 2 Basic procedures of drilling engineering valuation standards for the service company

2.2 Standard well management

According to standardized engineering projects, cost items, pricing methods, and reasonable engineering consumption and costs, model projects regarding several standard wells are established in line with the parameters related to typical wells of the actually drilled wells in this oil and gas area in recent years. These model projects are used for scientifically making the investment decision and organizing the drilling production. The estimated indicators, the specific forms of standard wells and the basis for the management of standard wells, mainly have the following functions: (1) visualizing the main drilling parameters, engineering quantities, and costs with highly clear and transparent information; (2) enabling construction companies to optimize the preparation of exploration and development plans and annual drilling investment plans based on that of standard wells; (3) enabling construction companies to optimize the measures workload and investment budgets based on the implement quota design of standard wells; (4) allowing both party A and party B to directly sign annual general contracts based on the estimated indicators related to standard wells; (5) allowing both party A and party B to jointly formulate the encouraging drilling contract terms according to the quantity list of standard wells; (6) enabling service companies, in a scientific and efficient way, to organize service teams according to the engineering parameters of standard wells.

3 Analysis methods of cost-saving and efficiency-improving drilling measures

3.1 Analysis of drilling productivity levels

At the end of December 2017, four construction companies, including Southwest, Zhejiang, Chuanqing and Greatwall Drilling, drilled 267 wells with a total drilling footage of 121.14×104m and an average well depth of 4,537m. The average investment and production rate of a single well were RMB 50.21 million and 6.11×104m3, respectively. An established template for drilling technology shortens the drilling cycle by 40%~60% compared with the early stages of development. In line with the sequence of drilling time of each well, the corresponding learning curves (see Fig. 3) are made based on the average drilling rate index (m/d), which is defined by the well depth (m) divided by the drilling cycle (d). The learning curves basically remain horizontally stable. According to the preliminary research, it is realized that the drilling technology system for Sichuan-Chongqing shale gas development has basically formed and satisfied the large-scale production conditions. In addition, the drilling productivity level tends to be stable.

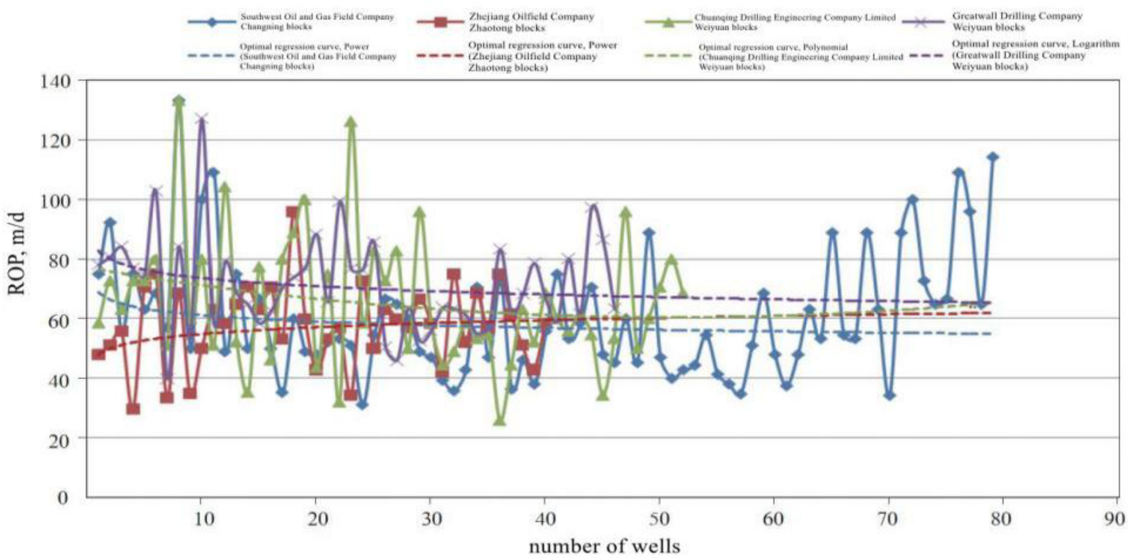

Figure 3 Variation tendency of integrated ROP in the Sichuan-Chongqing shale gas area.

3.2 Estimated quota preparation

(1) Analyzing the number of standard wells on a platform

According to the data analysis of 50 developed platforms, the number of horizontal wells is 3 to 10, with an average value of 5.78 on a single platform. Twenty-eight among the 50 platforms have six horizontal wells. In addition, economic evaluation studies show that the optimal number of horizontal wells is 4 to 8, and the intermediate number is 6 in the industrialized platform for shale gas wells in the Fuling area. Based on the above analysis, a conclusion can be drawn that six standard horizontal wells suit one platform optimally, where two standard 2D (two-dimensional) horizontal wells are deployed in the middle of the platform and the other four 3D (three-dimensional) horizontal wells around the platform (see Fig. 4).

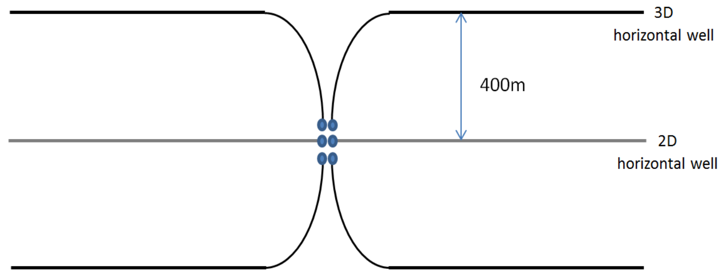

Figure 4 Schematic diagram of horizontal well design on the platform

(2) Analyzing the key parameters of standard wells on a platform

The average vertical depths of horizontal wells are respectively optimized to be 2,400m in Zhaotong, 2,800m, 3,750m, and 4,250m in Changning, 3,200m, 3,750m, and 4,250m in Weiyuan, and 3,200m, 3,750m, and 4,250m in Luzhou and Western Chongqing. The length of the horizontal section is 1,500m, and the interval of drifts in horizontal sections is 400m. The average number of fracturing sections is 21. The number of standard wells in five blocks is 26, with both 2D and 3D horizontal types.

(3) Analyzing the main technical parameters of standard wells

Wells with an average depth approximately equivalent to that of drilled wells are chosen as the typical reference wells. Based on the mature supporting technologies and information related to the well history and drilling engineering design of the reference wells, the well structure, duration of each well section and every drilling process are calculated, and the drilling cycle of standard wells is obtained.

Drilling technical parameters of 2D horizontal wells: well structure for the fourth spudding. The kick-off point is selected in the well section of the fourth spudding and 200-450m above the vertical depth of target point A. The drilling rate is calculated based on the average drilling rate of each well section.

Drilling technical parameters of 3D horizontal wells: well structure for the fourth spudding. The well path of "vertical–increasing–twisting–stable–increasing" is adopted, and calculations are made based on a well spacing of 400m. The upper kick-off point is at 100-300m of the third spudding section, and the lower kick-off point is at 200-450m above the vertical depth of target point A. The drilling rate is calculated based on the average drilling rate of each well section. Table 1 shows the measured results of structural parameters regarding the standard wells in a block.

Table 1 Well structure parameters of standard wells in a block

Standard well number	Well section	2D horizontal well		3D horizontal well	
		Well depth（m）	Section length（m）	Well depth（m）	Section length（m）
Standard Well 1（buried depth 3200m）	First section	50	50	50	50
	Second section	700	650	700	650
	Third section	2,900	2,200	3,100	2,400
	Fourth section	4,950	2,050	5,200	2,100
Standard Well 2（buried depth 3750m）	First section	50	50	50	50
	Second section	900	850	900	850
	Third section	3,200	2,300	3,400	2,500
	Fourth section	5,500	2,300	5,750	2,350
Standard Well 3（buried depth 4250m）	First section	50	50	50	50
	Second section	1,200	1,150	1,200	1,150
	Third section	3,700	2,500	3,900	2,700
	Fourth section	6,000	2,300	6,250	2,350

(4) Preparation of and optimization methods for the estimated quota of standard wells

Taking into consideration the template for the estimated quota and the above-mentioned engineering technical parameters of standard wells, and using related process parameters of typical wells, the budget quotas of 26 standard wells in five blocks, including Zhaotong, Changning, Weiyuan, Luzhou, and Western Chongqing, can be drawn up.

By analyzing the advanced indicators and corresponding cost-saving and efficiency-improving technical measures of drilled wells in each block, it can be found that the mechanical drilling speed of each section is increased by 15% through adopting the speed-up measures that optimize the drilling bits and drilling tools and enhance the drilling parameters（Li H, 2025; Ren G et al., 2025）. Table 2 exemplifies the calculation results of the drilling cycles of 3D horizontal wells in a certain block.

Table 2 Drilling cycles of 3D (three-dimensional) standard wells in a block

Well section	Standard well 1		Standard well 2		Standard well 3	
	Current level（d）	After speeding up（d）	Current level（d）	After speeding up（d）	Current level（d）	After speeding up（d）
First section	3	3	3	3	3	3
Second section	9	9	11	10	13	12
Third section	32	28	29	26	29	26
Fourth section	37	35	43	42	48	46
Total	81	75	86	81	93	87

3.3 Preparation of budget quotas

(1) Overall preparation of budget quotas

Considering that the preparation of the 2021—2030 plan requires the comparison and optimization of multiple plans and scenarios, three sets of drilling budget quotas have been made based on three scenarios.

1)Preparation of budget quotas for existing productivity levels. Under the existing drilling technology and productivity levels, we lay down a set of budget quotas with respect to the information of typical wells, including engineering design, summary, approximate budget, bidding contract, settlement and other data in each block (see Table 3).

2) Preparation of budget quotas considering the increasing price. Under the current management mode and conditions, we comprehensively analyze the price increases, including labor, equipment and materials and the macro situation from 2016 to 2018. Meanwhile, based on the budget quotas for current productivity levels, we laid down a set of budget quotas with reference to the overall price increase of 10%.

3)Preparation of budget quotas considering the cost-saving and efficiency-improving measures. Under the existing productivity level, we lay down a set of budget quotas to comprehensively implement the “three unifications” measures, i.e., unified pricing methods, unified incentives, and unified resource allocation.

Table 3 Preparation of drilling budget quotas

Quota category	Serial number	Item names	Unit	Comprehensive unit price	Preparation method
Pre-drilling engineering budget quota	1	Survey engineering costs	RMB/well	21,800	Shared equally by sixwells, pre-drilling design
	…				
Drilling project budget quota	1	Construction costs	RMB/d	75,000	Comprehensively considering the daily drilling contract costs of the drilling companies, including Chunqing, Bohai and Zhongyuan, and the daily costs of the ZJ50 drilling rig approved in the 2003 Budget Quota Related to Drilling System Engineering for Sichuan Oil and Gas Field.
	…				

Continued

Quota category	Serial number	Item names	Unit	Comprehensive unit price	Preparation method
Completion budget quota	1	Fracturing construction costs	RMB/ section	520,000	With reference to the Southwest Oil and Gas Company's quotas and on-site market price
	…				

(2) Adjustment and optimization methods of budget quotas

Under the existing production level, we adopt a series of adjustments and optimization methods and lay down the budget quotas, considering the implementation of supporting measures to reduce costs and improve efficiency.

1) Adjustment range. According to the three main lines including management, technology and policy, overall consideration is given to the supporting measures to reduce cost and increase efficiency in 11 aspects, including daily drilling costs and coasts in fracturing construction, environmental treatment, power supply, top drive service, rotary steering service, well logging operation, mud logging operation, cementing operation, coiled tubing service, and bulk materials.

2) Adjustment methods. The adjustment in daily drilling costs and fracturing construction costs is selected to illustrate the optimized analysis method considering cost saving and efficiency improvement.

With its drilling productivity in the first three years, the ZJ50 drilling rig is calculated with an annual average of 191 effective drilling days and an average daily cost of RMB 75,000. Comprehensively taking into account the favorable weather and natural environment in the Sichuan-Chongqing area, the workload guaranteed by large-scale production, the unified command and coordination by PetroChina Sichuan-Chongqing Shale Gas Front Command, and the fact that the ZJ50 drilling rig can work effectively in 350 days per year, the ZJ50 drilling rig is expected to work effectively 320 days per year under large-scale production. About 30% of RMB 75,000, the daily drilling costs, is diesel costs, which is closely related to the annual overall drilling production time but has nothing to do with the annual effective drilling time. However, about 70% of the costs, i.e., equipment depreciation, is closely related to the annual effective drilling time. Therefore, the optimized and adjusted daily drilling costs are RMB 53,836 per day, which equals RMB 75,000 per day multiplied by the sum (including 30% + 70% × 191d ÷ 320d), and decreases the costs by 28.2%. The number of sections under fracturing operation doubles from 1.5-2.0 to 3.0-4.0 per day. The fracturing operation costs for single sections reduce from RMB 520,000 to RMB 338,000, showing a reduction of 35%. When the annual effective working time of the rig is greatly improved, the production efficiency of the entire drilling operation lines, such as well logging, mud logging, and cementing, is accordingly improved, and the production unit costs are reduced significantly.

3.4 Preparation of estimated indicators

Estimated indicators are composed of indicator numbers, basic data, and quantity list pricing. The basic data is directly determined by the basic data of the estimated quota. Single well costs equal the sum of drilling engineering costs, other construction costs, reserves and loan interest. Unit cost equals the single well costs divided by the well depth. It is stipulated that the engineering measurement costs equal the comprehensive unit price multiplied by the quantities, and the comprehensive unit price is directly determined by the budget quotas. Moreover, the quantities are directly determined by the estimated quotas. The imputed indicators of 26 drilling projects are developed based on two-dimensional and three-dimensional horizontal wells.

3.5 Preparation of imputed indicators

Imputed indicators, further integrated on the basis of estimated indicators, comprise three parts, including indicator numbers, basic data, and quantity list pricing. The basic data is directly derived from the corresponding items contained in the imputed indicators, and the quantity list pricing is directly calculated with the relevant parameters of the imputed indicators. The quantity measurement is divided into three types: (a) the "well" is taken as the unit and the quantity is defined by 1; (b) the time "d" is taken as the unit, and the drilling cycle is defined by T1, whereas the completion cycle is referred to T2; (c) the well depth "m" is taken as the unit and the total well depth is defined by H. The imputed indicators of 26 drilling projects are developed based on two-dimensional and three-dimensional horizontal wells.

3.6 Preparation of reference indicators

The imputed indicators of single well cost are used to obtain the reference indicators related to two-dimensional and three-dimensional horizontal wells with a horizontal section length of 1,500m. Furthermore, making use of the cost per unit length to multiply the corresponding length of the horizontal section associated with the fourth spudding of all wells, the reference indicators of horizontal section lengths of 2,000m, 2,500m, and 3,000m for various wells are obtained. The comprehensive reference indicators concerning standard wells are obtained based on the estimation of 6 horizontal wells on a platform (including twotwo-dimensional horizontal wells and four fourthree-dimensional ones). The average reference indicators are calculated with respect to the sum divided by 6, where the sum is defined by adding up the reference indicators of respective wells. Finally, 468 reference indicators are obtained for three drilling scenarios, three buried depths, and four horizontal section lengths in 5 blocks (see Table 4).

Table 4 Examples of drilling engineering reference indicators

Serial number	Indicator number	Block	Target layer	Buried depth (m)	Well types	Well shapes	Well structure	Vertical depth (m)	Number of fracturing sections (section)	Horizontal section length corresponds to drilling investment (ten thousand yuan)				Note
										1,500m	2,000m	2,500m	3,000m	
1	YYQCKZB 2018-001	**	Longmaxi-Wufeng Formation	<3,500	Development well	Horizontal well	Forth section	2,400	21	5***	6***	6***	7***	Developed
2	YYQCKZB 2018-002	**	Longmaxi-Wufeng Formation	<3,500	Development well	Horizontal well	Forth section	2,800	21	5***	6***	7***	8***	Developed
	…													
13	YYQCKZB 2018-013		Longmaxi-Wufeng Formation	4,000 ~ 4,500	Development well	Horizontal well	Forth section	4,250	21	6***	7***	8***	9***	

3.7 Drilling Investment Calculation

The total measured investment for development wells is obtained with respect to equation (1). It is the summation of multiplications between the reference indicators of drilling engineering and the number of development wells of respective blocks. The number is determined by the corresponding scale of production construction for the special development of shale gas in 2021-2030. The target blocks of this study include Zhaotong, Changning, Weiyuan, Western Chongqing, and Luzhou. These measured results are used for overall investment calculation and economic evaluation.

$$V = \sum_{i=1}^{N} C_i W_i \tag{1}$$

Where V is the total investment in drilling engineering, ten thousand RMB; N is the number of blocks; Ci is the reference indicators of drilling engineering for a standard well in a certain block platform, ten thousand RMB/well; Wi is the number of drilling wells in each block.

The new reference indicators related to reducing cost and increasing efficiency of drilling engineering decrease by 20% to the existing reference indicators of horizontal drilling engineering. On the given conditions of the scale of production construction, the measured investment of development wells has decreased by RMB 33.2 billion, showing significant results in cost reduction and efficiency increase. The internal return rate increases by 4.28%, exceeding 8% of the standard value of the evaluation indicators and meeting the requirements of the investment decision.

4 Conclusions

(1) To achieve the target of large-scale and high-quality development of unconventional oil and gas, for example, shale gas, two measures, including increasing the ultimate recoverable reserves (EUR) of a single well and significantly reducing project investment, are the overall idea and direction to reduce costs and improve efficiency. The efficient development model is summarized with respect to an integrated approach that combines the integrated management, platform horizontal wells, ultra-large fracturing and factory operations. For integrated management, the combination of an integrated pricing method and standard wells management is the most basic and critically effective way for cost reduction, efficiency increase, and investment control.

(2) North American experience shows that there is a development process for reducing cost and increasing efficiency of unconventional oil and gas development, such as shale gas. The drilling investment and costs generally continue to fluctuate and decline, but the decline is getting increasingly smaller. China is still in the initial stage of the large-scale development of shale gas. After 3-5 years of development, it is expected that the unit drilling investment and cost are likely to decrease by more than 20% compared with the current production level.

(3) The analysis method for drilling projects cost saving and efficiency improvement in this paper only exemplarily illustrates the application in medium and long-term development planning. The method is actually applicable to the entire process of drilling investment management for oil and gas exploration and development projects, including decision-making, designing, preparation, construction and completion.

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