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Kopchenova Daria Mikhaylovna, student,
Peter the Great St.Petersburg Polytechnic University

Shishov Sergei Alekseyevich, student,
Peter the Great St.Petersburg Polytechnic University

ECONOMIC EFFICIENCY ASSESSMENT OF HYDRAULIC FRACTURING APPLICATION

Abstract. The article presents a calculation of the economic efficiency of hydraulic fracturing (HF) for an oil well. Capital and operating expenditures are determined, NPV, PI and IRR are calculated along with the payback period, and a sensitivity analysis of key parameters is performed.

Keywords: Hydraulic fracturing, economic efficiency, net present value, payback period, sensitivity analysis.

The economic efficiency of HF is determined by the profit from incremental production. The calculation includes operating expenses: material costs, labor costs, insurance contributions, depreciation and other expenses.

HF was performed on a well with an initial flow rate of 6.72 t/day. After the treatment the flow rate rose to 36.96 t/day in the first month, then gradually declined to the initial level over 18 months. The total incremental oil production amounted to 6,131.43 t, and liquid production to 7,258.14 t.

Next, the material costs must be calculated. Table 1 shows the raw materials and supplies used for the hydraulic fracturing operation.

Table 1

Material costs

Item	Unit price, RUB	Quantity	Cost, RUB
Fracturing fluid, m^3	5,000	10	50,000
Proppant, t	36,000	3	108,000
Displacement fluid, m^3	2,000	8.78	17,560
Fuel, L	70	8000	560,000
Total			1,491,560

Electricity consumption is determined by a specific rate of 75 kWh/t and the incremental liquid production for the month. In month zero consumption is zero, since HF is performed in the first month.

HF crew: a supervisor, 2 blender operators, 8 pumping-unit operators, a control-station operator, 2 drivers, and a laboratory technician. Duration – 96 h. Insurance contributions – 30.5% of wages. The payroll calculation is shown in Table 2.

Table 2

Payroll calculation

Position	Number of employees	Shift rate, RUB/shift	Number of shifts	Wages for work performed (96 hours), RUB	Insurance contribution, RUB
HF operations supervisor	1	9,600	3	28,800	8,784
Blender operator	2	6,000	4	48,000	14,640
Pumping unit operator	8	5,400	4	172,800	52,704

Control and monitoring station operator	1	6,240	8	49,920	15,225.6
Special vehicle driver	2	4,800	3	28,800	8,784
Laboratory technician	1	4,200	2	8,400	2,562
Total				336,720	102,700

Let us calculate the capital expenditures and depreciation charges for the equipment.

The monthly depreciation rate is calculated using the formula:

$$H_{Depreciation} = \frac{\frac{1}{n}}{12} \cdot 100\% \qquad (1)$$

where n – useful life, years.

Depreciation is calculated using the formula:

$$A = H_{Depreciation} \cdot C_n \qquad (2)$$

where C_n – initial cost, RUB.

The calculation results are shown in Table 3.

Table 3

Capital expenditures and depreciation charges

Item	Quantity	Initial cost, RUB million	Total cost, RUB million	Useful life, years	Monthly depreciation rate, %	Depreciation, RUB
4AH-700	3	7.00	21.00	8	1.04	218,750
УСГ-30	1	4.50	4.5	8	1.04	46 875,00
Manifold	1	0.35	0.35	7	1.19	4,166.67
Cameron 15,000 PSI wellhead	1	0.28	0.28	7	1.19	3 333.33
Retrievable Seit 15,000 PSI packer	1	0.29	0.29	2	4.17	12 083.33
Scraper	1	0.22	0.22	2	4.17	9,166.67
Total			26.64			294,375

Capital expenditures amount to RUB 26,640,000, and depreciation to RUB 294,375.

Purchasing all the equipment outright is not economically viable -owing to the high investment required, so part of it is purchased and part is leased – this ensures returns and payback. Leasing the HF fleet (control station, tanks, sand truck) – RUB 1,055,500.

The mineral extraction tax (MET) rate at the field is RUB 14,532.12/t.

The amount of mineral extraction tax is calculated using the formula:

$$MET = C_{MET} \cdot \Delta Q \qquad (3)$$

where ΔQ – incremental oil production for the month, t; C_{MET} – mineral extraction tax rate (equal to RUB 14,532.12/t at this field), RUB/t.

The monthly sales revenue is calculated using the formula:

$$B = Ц \cdot \Delta Q \qquad (4)$$

where P – oil sales price, RUB,

$$Ц = \overline{Ц} \cdot \overline{K} \cdot 7.3 - TR \qquad (5)$$

where $\overline{K}$ – average annual USD/RUB exchange rate, $\overline{K} = 84.69$ RUB/USD; $\overline{Ц}$ – average annual Urals oil price Urals, $\overline{Ц} = 62.57$ USD/bbl; TR – transportation costs (assume TR = RUB 10,000).

$$Ц = 62.57 \cdot 84.69 \cdot 7.3 - 10{,}000 = 28{,}681.16\ RUB.$$

Production costs are calculated as the sum of material costs, wages, insurance payments, depreciation charges and other expenses.

Other expenses consist of the mineral extraction tax (MET), calculated using formula (3), and the cost of leasing the HF fleet.

In month zero only capital expenditures are accounted for, since this is when the necessary equipment is purchased.

Earnings before tax (EBT) is calculated using the formula:

$$EBT = B - OPEX \tag{6}$$

The income tax rate is taken as 25%; the tax itself is calculated using the formula:

$$H_{np} = EBT \cdot 0.25 \tag{7}$$

Net profit is calculated using the formula:

$$NP = EBT - H_{np} \tag{8}$$

Cash flow is calculated using the formula:

$$CF = NP + A - CAPEX \tag{9}$$

where A – depreciation, RUB; CAPEX – capital expenditure, RUB (included only in month zero).

Let us calculate the discount factor, used to bring future cash flows to their present value:

$$K_{д} = \frac{1}{(1 + r_{м})^t} \tag{10}$$

where $r_{м}$ – monthly discount rate, %;

t – period number.

$$r_{м} = \frac{r}{12} \tag{11}$$

where r – annual discount rate (taken as r = 15%), %.

$$r_{м} = \frac{15}{12} = 1.25\%$$

Discounted cash flow – the value of future cash flows brought to their present value:

$$DCF = K_{д} \cdot CF \tag{12}$$

NPV (integral economic effect) is the value, brought to the initial point in time, of income in excess of the return of investment and of interest equal to the discount rate set by the investor.

NPV is calculated as the difference between the discounted cash inflows and outflows over the entire investment period.

$$NPV = \sum_{t=0}^{T} \frac{P_t}{(1+E_H)^t} - \sum_{t=1}^{T} \frac{Om_t}{(1+E_H)^t} \tag{13}$$

$$NPV = \sum_{t=0}^{T} \frac{Revenue_t - K_t - Э_{npt} - H_t + A_t}{(1 + E_H)^t} \tag{14}$$

where Pr_t – cash receipts during period t forming the inflow; Om_t – cash payments during period t forming the outflow; T – calculation period; E_H – discount rate adopted for evaluating the investment project; B_t – revenue in year t, K_t – capital investment in fixed assets in year t, $Opex_t$ – operating expenses (production, commercial and administrative) in year t; N_t – tax payments not included in production costs, in year t, A_t – depreciation charges in year t.

$$NPV = 29\,851\,814{,}20\ RUB.$$

The NPV calculation is shown in Table 4.

Table 4

NPV calculation

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Incr. production	0.00	846.72	828.41	706.21	640.48	541.65	486.62	420.49	349.01	306.50	249.20	213.18	173.07	123.54	103.94	71.83	47.33	22.26	0.99
Revenue	0.00	24.28	23.76	20.25	18.37	15.54	13.96	12.06	10.01	8.79	7.15	6.11	4.96	3.54	2.98	2.06	1.36	0.64	0.03
OPEX, incl.	0.00	15.59	13.07	11.19	10.17	8.65	7.80	6.78	5.68	5.02	4.14	3.58	2.96	2.20	1.90	1.40	1.02	0.64	0.31
Material costs	0.00	1.49	0.74	0.63	0.57	0.48	0.43	0.38	0.31	0.27	0.22	0.19	0.15	0.11	0.09	0.06	0.04	0.02	0.00
Wages	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Insurance	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Depreciation	0.00	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Profit	0.00	13.36	12.04	10.26	9.31	7.87	7.07	6.11	5.07	4.45	3.62	3.10	2.52	1.80	1.51	1.04	0.69	0.32	0.01
EBT	0.00	8.70	10.69	9.07	8.20	6.89	6.16	5.28	4.33	3.77	3.01	2.53	2.00	1.34	1.08	0.66	0.33	0.00	-0.28
Income tax	0.00	2.17	2.67	2.27	2.05	1.72	1.54	1.32	1.08	0.94	0.75	0.63	0.50	0.34	0.27	0.16	0.08	0.00	0.00
Net profit	0.00	6.52	8.02	6.80	6.15	5.16	4.62	3.96	3.25	2.83	2.26	1.90	1.50	1.01	0.81	0.49	0.25	0.00	-0.28

Cum. DCF	DCF	DF	CF	CAPEX
-26.64	-26.64	1.00	-26.64	26.64
-19.91	6.73	0.00	6.82	0.00
-11.80	8.11	0.00	8.31	0.00
-4.96	6.84	0.00	7.09	0.00
1.16	6.13	0.00	6.44	0.00
6.29	5.13	0.00	5.46	0.00
10.85	4.56	0.00	4.91	0.00
14.75	3.90	0.00	4.25	0.00
17.96	3.21	0.00	3.54	0.00
20.75	2.79	0.00	3.12	0.00
23.01	2.25	0.00	2.55	0.00
24.92	1.91	0.00	2.19	0.00
26.46	1.55	0.00	1.79	0.00
27.57	1.11	0.00	1.30	0.00
28.50	0.93	0.00	1.11	0.00
29.16	0.65	0.00	0.79	0.00
29.60	0.45	0.00	0.54	0.00
29.84	0.24	0.00	0.29	0.00
29.85	0.01	0.00	0.01	0.00

Next, let us plot the cumulative discounted cash flow (Figure 1):

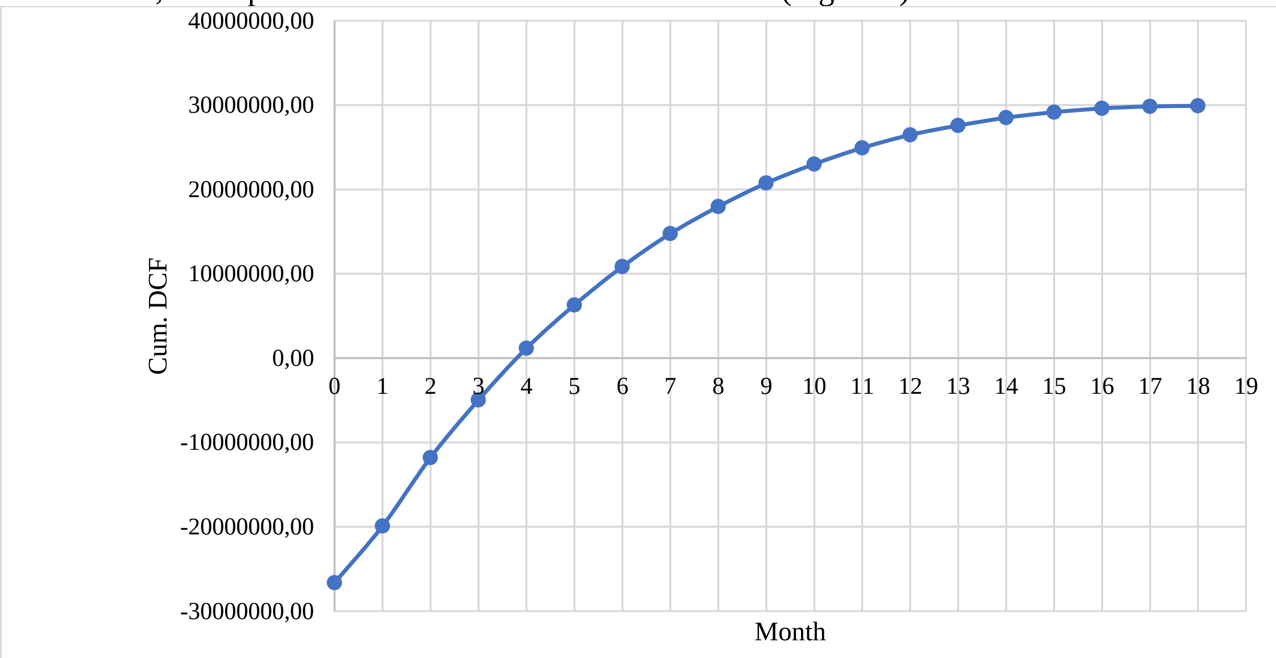

Figure 1. Cumulative discounted cash flow chart

The discounted payback period (DPP) is the time from the start of the project to the point when the cumulative discounted cash flow becomes positive and remains non-negative thereafter.

The discounted payback period of the project can be approximately determined from the point where the chart crosses the x-axis. There is also a formula for calculating it:

$$\sum_{t=0}^{T^*} \frac{Revenue_t - K_t - Э_{npt} - H_t + A_t}{(1 + E_H)^t} = 0 \qquad (15)$$

where N – the number of the month in which the cumulative DCF is negative;

$$DPP = 3 + \frac{|-4\,964\,115{,}33|}{6\,129\,085{,}65} = 3.81\ mo.$$

The project payback period is 3.81 months (3 months 25 days). The profitability index (PI) is the ratio of NPV to discounted investment, plus one. The project is effective if PI > 1.

Let us calculate it using the formula:

$$PI = 1 + \frac{Ч}{DCapEx} \qquad (16)$$

where DCapEx – discounted value of the capital expenditures, RUB.

$$DCapEx = CAPEX \cdot K_{\partial} \qquad (17)$$

$$DCapEx = 26{,}640{,}000 \cdot 1 = 26{,}640{,}000\ RUB.$$

$$PI = 1 + \frac{29\,851\,814{,}20}{26{,}640{,}000} = 2{,}12$$

Internal Rate of Return (IRR) is the discount rate value at which the net present value becomes zero.

It is calculated from the following relationship:

$$\sum_{t=0}^{T} \frac{p_t}{(1+IRR)^t} = \sum_{t=0}^{T} \frac{Om_t}{(1+IRR)^t} \qquad (18)$$

$$IRR = 20\%$$

Investment projects in the oil and gas industry are subject to numerous risks, so managing them is an important task for timely identification and mitigation of threats. Based on the HF project analysis, the following risk groups were identified.

Geological and technological risks: uncertainty of the reservoir structure, fracture-model mismatch, breakthrough into the aquifer, insufficient flow-rate increase, accidents and complications.

Economic and financial risks: macroeconomic instability – falling oil prices and revenue, rising costs, more expensive credit when the key rate increases, currency fluctuations.

Regulatory and legal risks: tightening of subsoil-use requirements, tax changes, regulator claims, permit delays.

Operational risks: supply disruptions, poor-quality contractor work, low staff qualification, injuries and accidents.

Sensitivity analysis using the rational-range method (Table 5). To assess the elasticity of the project's NPV to changes in parameters, a sensitivity analysis was performed over a range of -20% to +20% of the base values.

Table 5

Sensitivity analysis

	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
Gasoline sales price, RUB million	4.25	10.42	16.59	22.76	29,85	35.10	41.26	47.43	53.60
Raw material and supplies price, RUB million	29.84	29.61	29.38	29.16	29,85	28.70	28.47	28.24	28.01
Gasoline sales volume, RUB million	17.22	20.15	23.08	26.00	29,85	31.85	34.78	37.70	40.63

The graphical results of the analysis are shown in Figure 2:

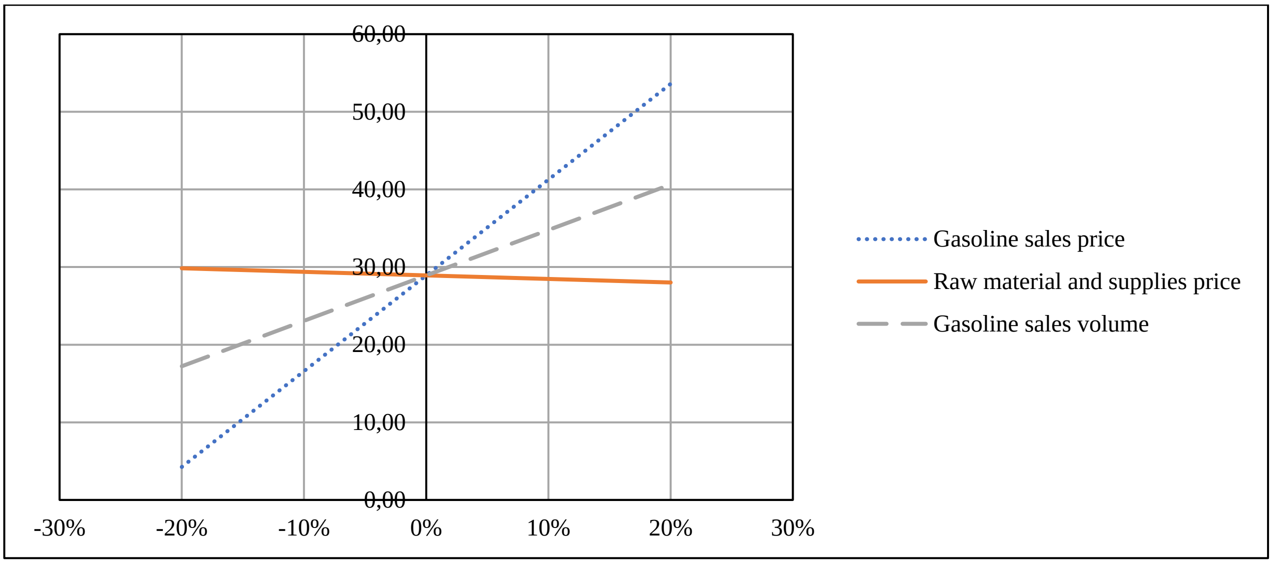

Figure 2. Graphical representation of the sensitivity analysis

The sensitivity analysis showed that the sales price is the most influential factor: a 20% decrease reduces NPV to RUB 4.25 million, while an increase raises it to RUB 53.60 million. Sales volume is also significant: at ±20% NPV ranges from RUB 17.22 to 40.63 million. Raw material prices have a weak effect: a 20% increase reduces NPV from RUB 29.85 to 28.01 million. The graphical analysis confirms that the project is most sensitive to price and sales volume, but resilient to changes in production costs. Therefore, risk management should focus mainly on price fluctuations and sales stability, while an increase in raw material costs does not pose a major threat.

Conclusion: The calculations performed show that applying HF to a well of the oil field is economically justified. The incremental oil production (6,131 t) generates revenue that covers all costs and yields a net present value of RUB 29.85 million with a payback period of under 5 months. The project demonstrates high profitability and resilience to key risks, which supports its practical implementation.

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