

# Financial Aspects of Technological Concept for Energy Efficiency Enhancement during Stripper Wells Development in Tomsk Region

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**Abstract.** The issue of operating costs cutting in terms of falling oil prices on the world market actualizes the challenge to find technological solutions to reduce electricity consumption during well operation. This is especially important for stripped-wells of small deposits in Tomsk region. The correlation analysis between the cost of oil production, electricity, heat and fuel consumption during the extraction of one ton of oil allowed the authors to focus on the financial aspect of such technological solutions like periodic well operation in the Shinginskoye field as well as to recommend the application of this method at the other fields in Tomsk region.

## 1. Introduction

Cost of oil production is one of the basic parameters determining the threshold of oil companies' financial stability. This issue has become even more relevant in the conditions of world energy prices fall on the world market [1, 2]. As a consequence, the issue of one oil barrel cost (Table 1) has become one of the most important stimuli for the technological innovations development [3]. As it could be seen from the Table 1, there is a significant difference in the amount of operational expenditures. In particular, operational expenditures in the Great Britain are twice higher than in Norway.

**Table 1.** Overall cost, capital and operational expenditures to produce one barrel of oil

	Overall cost	Capital expenditure	Operational expenditure
United Kingdom	52.5	21.8	30.7
Brazil	48.8	17.3	31.5
Canada	41.0	18.7	22.4
United States	36.2	21.5	14.8
Norway	36.1	24.0	12.1
Angola	35.4	18.8	16.6
Colombia	35.3	15.5	19.8
Nigeria	31.6	16.2	15.3
China	29.9	15.6	14.3
Mexico	29.1	18.3	10.7
Kazakhstan	27.8	16.3	11.5
Libya	23.8	16.6	7.2
Venezuela	23.5	9.6	13.9
Algeria	20.4	13.2	7.2
Russia	17.2	8.9	8.4
Iran	12.6	6.9	5.7
UAE	12.3	6.6	5.7
Iraq	10.7	5.6	5.1



Saudi Arabia	9.9	4.5	5.4
Kuwait	8.5	3.7	4.8

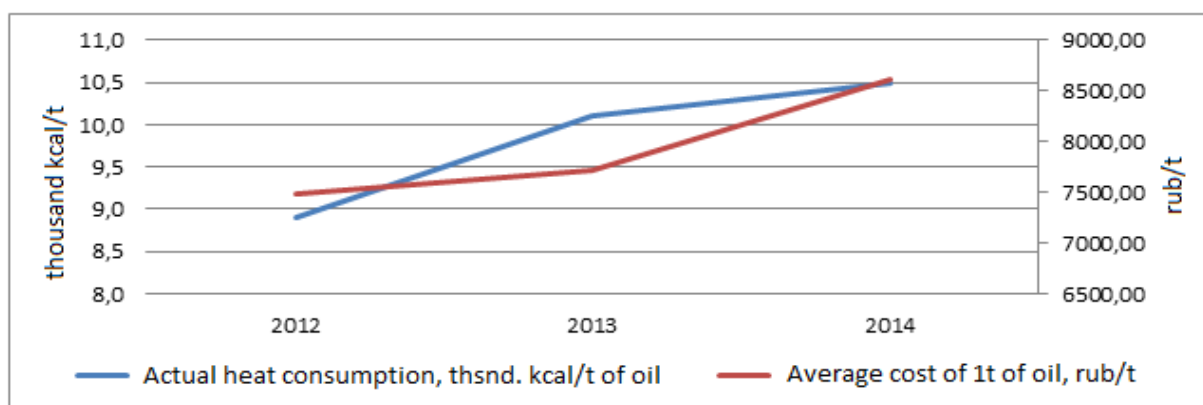
The reducing operating expenditures were the major factor for shale oil production rise in the USA. Indirect evidence of this is the fact that the number of patents related to the introduction of innovations in the production industry has more than doubled from 2005 to 2010. Besides, the reduction of operating costs contributed to the fact that electricity prices in the United States for industrial companies, including oil producers, are almost one and a half times lower than for the residential sector. Compare – in 2014 the cost of electricity for the citizens was 12.5 cents per 1 kWh, while for industry 7.01 cents per 1 kWh [4].

It should be noted that the oil cost in Russia is rising due to a number of factors, such as: inflation, complexity of production, infrastructure and geological conditions (Table 2).

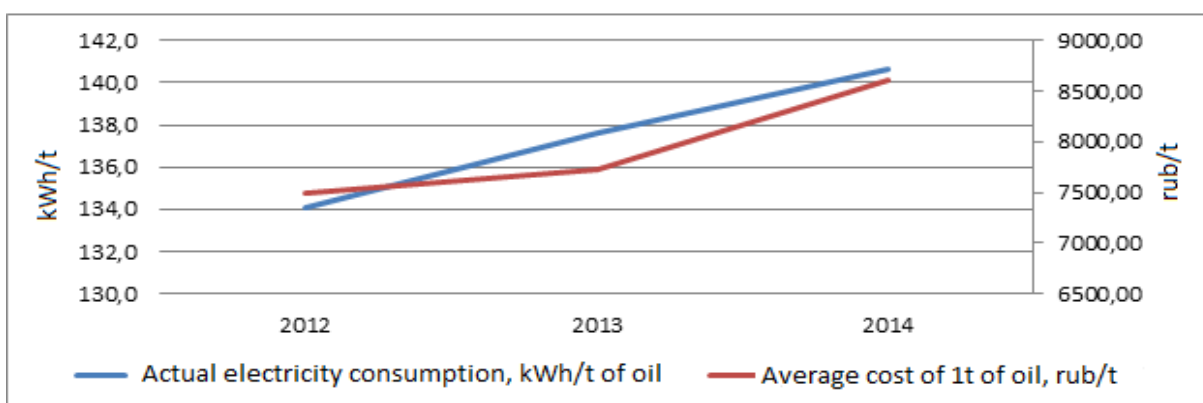
**Table2.** Oil production cost in Russia, rub/t [5]

	2012	2013	2014	2015
I quarter	7476.9	7420.5	8655.5	9812.2
II quarter	7194.9	7312.5	8666.4	10123.8
III quarter	7600.7	7853.4	8845.2	9665.1
IV quarter	7695.1	8307.9	8246.3	8784.6

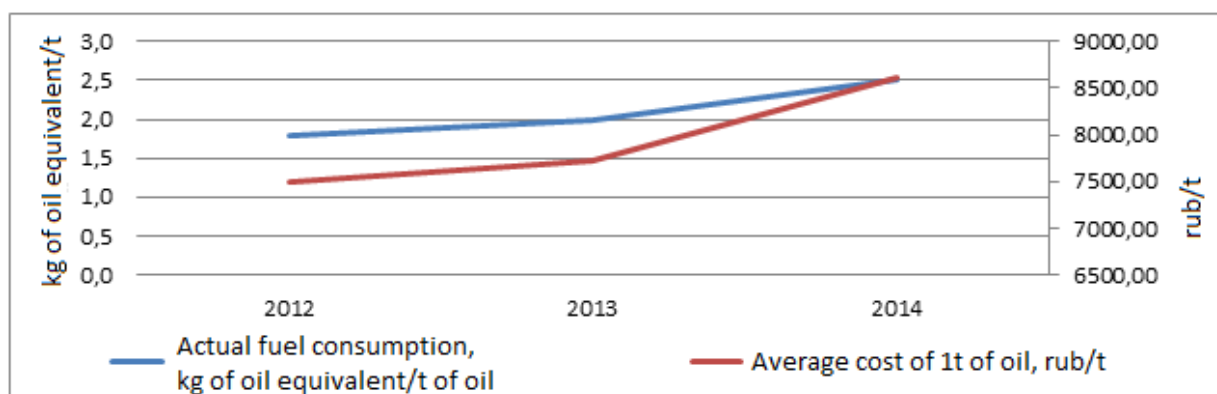
The figures below illustrate the tendency of heat, electric and fuel energy rising in reliance on one ton of produced oil and oil production cost (Figure 1, 2, 3).



**Figure 1** Correlation of actual heat consumption per 1 ton of oil and average oil production cost (rub/t).



**Figure 2** Correlation of actual electricity consumption per 1 ton of oil and average oil production cost (rub/t).



**Figure 3** Correlation of actual fuel consumption per 1 ton of oil and average oil production cost (rub/t).

As it can be seen from these figures, there is a difference between the growth rates of oil production cost and energy consumption costs, which defines the objectives of the companies in the development of programs to improve the energy efficiency of the production processes.

In addition, the data in Table 3 shows mixed dynamics in electricity consumption for different production methods [5].

**Table 3.** Actual electricity consumption per one unit of specific product

	Electricity consumption per one ton of produced oil, kWh		
	2012	2013	2014
Oil production including gas condensate - total	134.1	137.6	140.6
- steam treatment	69.3	67.7	54.2
- gas lift	154.6	153.2	3.1
- other	139.3	142.9	148.0

This issue is extremely considerable for small low production rates fields. In Russia, small deposits are mainly developed by small producing companies, which, due to the scale of its activities, credit and tax state policy, have significant financial difficulties for the realization of innovative investment programs. For example, Tomsk region, the mineral and raw material base of which is characterized by a large number of small and medium-sized fields. According to Tomsknedra, 131 deposits of hydrocarbons were opened in the region, among which 102 are oil, 21- oil and gas, 8 - gas condensate. From 131 fields, 112 are referred to small, while 6 are referred to large. 34 production companies are operating on the territory of the region, but only 15 are involved in the production of hydrocarbons [6]. Therefore, there is an attempt to implement such technological innovations that will improve the profitability at minimal financial input [7, 8].

## 2. Periodic well operation

One of the most effective ways to solve the above mentioned issue is the introduction of periodic well operation (PWO), which allows significantly to reduce costs, in particular via reduction of energy consumption during oil extraction [9]. Such way of stripped wells exploitation is based on the cycles of oil extraction and oil accumulation in the deposit. Accumulating cycle varies from 30 min to 2 hours.

The aim of the study is a comparative analysis of the influence of short-term well operation modes on energy consumption and the definition of energy efficiency of such method under the conditions of Tomsk region, in particular through the example of Shinginskoye field, which is developed by OOO "Gazpromneft-Vostok". After the exploration in 1971 and reaching of the flow rates of 5-15 m<sup>3</sup>/day, it was considered as cost-ineffective. Later in 2007, however, after the fracturing and reaching of inflows of about 150 m<sup>3</sup>/day, this deposit was put into operation.

The features of such operation mode are as follows:

1. on-operation well workover;

2. shifting of well to PWO mode during servicing and workover;
3. putting of new wells into production with the potential of less than 30 m<sup>3</sup>/day, initially in PWO mode [10].

### 3. Comparative analysis of PWO economic efficiency in the context of energy consumption

The following well operation methods were viewed to carry out the comparative analysis:

1. Nonstop oil production from the whole well stock.
2. Application of PWO technology for high-rate wells, i.e. at  $q \geq 80$  m<sup>3</sup>/day.

The calculation of economic efficiency in monetary term was based on the technical characteristics of electric centrifugal pumps of various capacities applied during oil production. The results are given in Table 4.

Table 4 Results

$q_{rated}$ , m <sup>3</sup> /day	35	50	80	100	124	For pumps of different power
Pump rate, m <sup>3</sup> /day	20-60	35-70	60-110	70-140	95-160	
$\eta$ , %	39	50	55	60	61	
Power, kW	20.35	22.63	33.02	38.29	46.88	
1 <sup>st</sup> Method						
Number of wells, n	25	40	30	25	12	
n, unit fraction	0.37	0.48	0.23	0.21	0.10	
$q_{actual}$ , m <sup>3</sup> /day	35.00	50.00	18.72	21.27	12.87	
$\Sigma Q$ , m <sup>3</sup> /day	875.00	2000.00	561.49	531.72	154.44	4122.65
w, kWh/day	488.40	543.12	792.48	918.96	1125.12	
W, kWh/day	12210.00	21724.80	23774.40	22974.00	13501.44	94184.64
W/Q, kWh/m <sup>3</sup>	13.95	10.86	42.34	43.21	87.42	
2 <sup>nd</sup> Method						
Number of wells, n	25	40	26	23	18	
n, unit fraction	0.37	0.48	0.52	0.57	0.58	
$q_{actual}$ , m <sup>3</sup> /day	35.00	50.00	8.95	12.21	15.39	
Q, m <sup>3</sup> /day	875.00	2000.00	232.76	280.77	277.01	3665.54
w, kWh/day	488.40	543.12	169.72	196.81	240.96	
W, kWh/day	12210.00	21724.80	4412.79	4526.64	4337.34	47211.57
W/Q, kWh/m <sup>3</sup>	13.95	10.86	18.96	16.12	15.66	
$\Delta W$ , kWh			209.32	330.64	1104.41	
$\Sigma \Delta W$ , kWh			5442.44	7604.76	19879.46	32926.67
$\Delta W/Q$ , %/m <sup>3</sup>			0.55	0.63	0.82	0.65
$\Delta Pq$ , rub/m <sup>3</sup>			93.53	108.34	287.06	150.61
$\Sigma \Delta Pq$ , rub/t			74.82	86.67	229.64	120.48
$\Delta Pt$ , rub/day			837.30	1322.57	4417.66	
$\Sigma \Delta Pt$ , rub/day			21769.78	30419.05	79517.86	131706.68

Where:

$q_{rated}$  – Pump rate

$\eta$  – pump efficiency;

$q_{actual} = q \cdot \eta$  – actual production rate considering electric centrifugal pump efficiency;

$Q_{35} = \sum_{i=1}^{n_{35}} q_{35}$  – total production rate for all pumps of one type;

$W$  – electric energy consumed by one pump;

$W_{35} = \sum_{i=1}^{n_{35}} w_{35}$  – electric energy consumed by all pumps of one type;

$W/Q = \frac{\sum_{i=1}^{n_{35}} w_{35}}{\sum_{i=1}^{n_{35}} q_{35}}$  – electric energy consumption per 1m<sup>3</sup> of produced crude oil;

$\Delta W = (W/Q_1 - W/Q_{11}) \cdot q_{actual}$  – electric energy saving by one electric centrifugal pump;

$\Delta W/Q = \frac{W/Q_1 - W/Q_{11}}{W/Q_1}$  – percent increase of pump power rate;

$\Delta Pq = (W/Q_1 - W/Q_{11}) \cdot k$  – saving on electricity cost per one unit of produced product ( $k$  – cost of 1 kWh), ( $\Sigma \Delta Pq$  – for all wells of one type);

$\Delta Pt = (W/Q_1 - W/Q_{11}) \cdot q_{actual} \cdot t$  – saving on electricity cost for a definite period of time ( $\Sigma \Delta Pt$  – for all wells of one type)

The obtained results show that shifting to periodic well operation will allow reducing electric energy consumption by all electric centrifugal pumps in average on 65%, whilst the cash saving on 1m<sup>3</sup> and 1 ton of produced oil in average will be 150.61 RUB and 120.48 RUB respectively.

#### 4. Conclusion

1. The successfully introduced and applied PWO mode shifted Shinginskoye field from low to high cost-effective fields.
2. The application of this technological mode is recommended for application during oil production in the other fields in Tomsk region.

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