Supplementary Materials: Creating an Energy Analysis Concept for Oil and Gas Companies: The Case of the Yakutiya Company in Russia

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1. General Information of JSC Yakutsk Fuel and Energy Company (Figure S1)

JSC Yakutsk Fuel and Energy Company has the gas enterprise possessing licenses for development of Srednevilyuysky and Mastakhsky gas condensate fields. Both fields are dated for one geological structure—the Hapchagaysky megashaft. JSC Yakutsk Fuel and Energy Company provides extraction of natural gas, and also prepared gas for delivery to the main gas pipeline. Delivery of gas to end users is carried out by the JSC "Sakhatransneftegaz." The company conducts the primary operating activities in the territory of the Republic of Sakha (Yakutia), Russian Federation. The region is characterized by a high degree of isolation from the outside world in view of the increased complexity of transport accessibility In this case influence of external competitors is minimized.

The Srednevilyuysky gas-condensate field lays in the territory of the Vilyuysky ulus of the Republic of Sakha (Yakutia), 410 km to the northwest from Yakutsk. The field was found in 1965 and in size of stocks of hydrocarbonic raw materials belongs to large. Experimental-industrial exploitation of the Srednevilyuysky gas-condensate field has been begun in 1975. The Srednevilyuysky gas-condensate field is the main object of operation, is in an initial stage of development. Balance reserves of gas on Srednevilyuysky GKM on 1/1/2015 on the category AB, C1, and C2 within a license allowances make 179 billion m^3. The saved-up selection for the same date has made 34.27 billion m^3, with a condensate of 2.02 million tons.

The Mastakhsky gas-condensate field is in a last developing condition, acts as the field regulator, and works in the period of peak loadings. Balance reserves of gas on Mastakhsky GKM within a license site on January 1, 2015, put it in the category C1 with 21 billion m^3, and in the category C2 with 3.9 billion m^3. The degree of clarity of stocks as of January 1, 2015 was 38.7%. In a total amount of gas production of JSC "Yakutsk Fuel and Energy Company," the production of Mastakhsky GKM in 2014 was 0.8% [24].

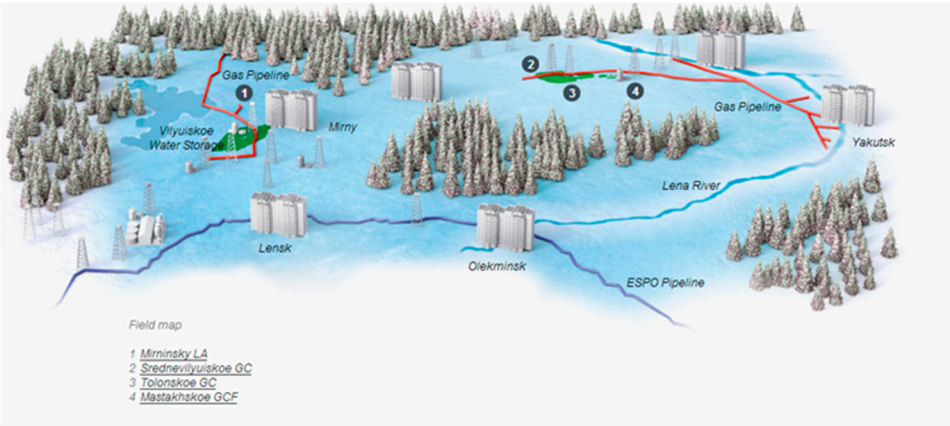

Figure S1. General information of JSC Yakutsk Fuel and Energy Company.

2. Data About Rocs and Erocs Calculation

For the calculation of ROCS, it is necessary to have two kinds of data, one is the dynamics of net profit, the other is dynamics of cost of sales. These data are available in open annual financial statements of the company (Table S1). Calculation of ROCS is made using Equation (5).

Table S1. Dynamics of net profit and cost of sales of JSC Yakutsk.

Year	2005	2006	2007	2008	2009
Net profit, thousand rubles	−318,169	−73,208	−172,097	−45,481	191,214
Cost of sales, thousand rubles	1,290,049	970,873	1,042,316	662,259	1,089,352
Year	2010	2011	2012	2013	2014
Net profit, thousand rubles	619,883	804,024	1,070,799	1,330,515	1,501,432
Cost of sales, thousand rubles	1,549,882	1,602,548	2,165,852	2,325,134	2,237,946

For the calculation of EROCS, it is necessary to have two kinds of data. The first one is the dynamics of gas production and condensate, and the second one is the dynamics of energy costs. During the reporting periods, the company consumed the following five types of energy resources: electric power, heat power, natural gas, motor fuel, and methanol as follows Figure S2.

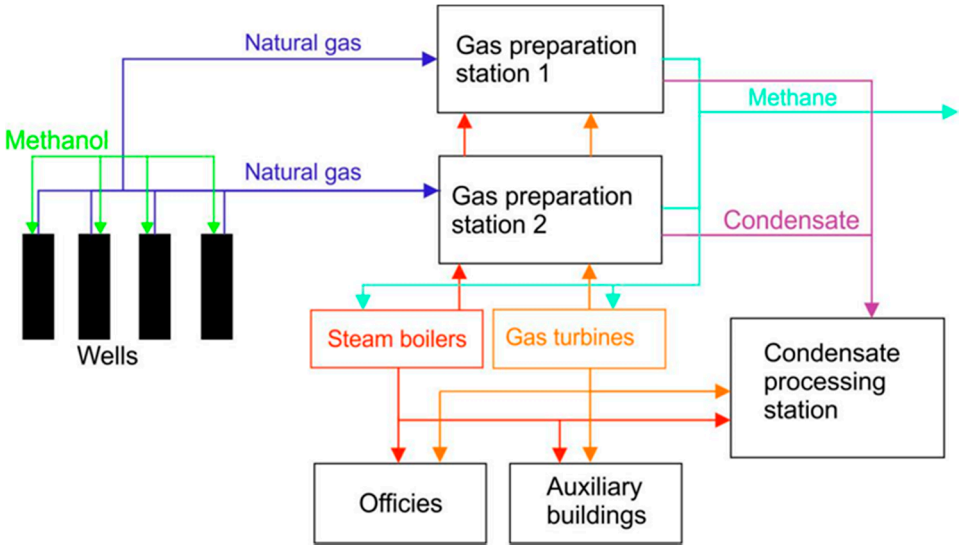

Figure S2. Schematically shows the flows of produced and consumed energy gas.

At the stage of extracting, gas electricity and heat power are used by installations. The generated energy is complex for installations on the process of preparation of hydrocarbon, installation of gas condensate, and in office and production space areas. At the same time, costs of electricity and heat will be considered based on the volume of gas used to produce them. Methanol is used for prevention of hydrate formation in wells. In this paper we will consider methanol as energy resource and consider its specific heat of combustion. Besides, automobile gasoline and diesel fuel are used to trade all types of works. The accounting of these energy resources will also be carried out from the specific heat of combustion. Besides offices and production departments at the gas fields, the company owns other offices in other cities. For the needs of these offices also purchased electric and thermal energy. The inclusion of these energy costs will be based on the average specific fuel consumption for generation in Russia, Table S2.

Table S2. Dynamics of hydrocarbons extraction and energy consumption in JSC Yakutsk Fuel and Energy Company.

Primary Data	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Sale of gas, 10^6 cum.	1296	1374	1381	1512	1614	1607	1590	1664	1685	1702
Sale of condensate, 10^3 t	74	82	78	80	85	85	89	87	88	86
Electricity consumption, 10^3 kWh										
Production of gas and condensate	4457	4687	4665	4700	5628	5421	5421	5598	5713	5659
Recycling of condensate	3425	2489	1950	2188	1785	2371	2394	2367	2856	2584
Specific fuel consumption for generation of electric energy	0.823	0.835	0.852	0.847	0.87	0.862	0.881	0.85	0.832	0.837
The consumption of heat energy, Gcal										
Production of gas and condensate	30,006	31,556	31,358	26,218	2739	27,471	26,177	28,351	29,308	29,034
Recycling of condensate	3910	2840	2500	2823	4523	3566	3563	3418	3357	3434
Specific fuel consumption for heat generation, Gcal	0.168	0.171	0.17	0.17	0.168	0.169	0.166	0.169	0.165	0.165
Additional purchase energy										
electricity, 10^4 kWh	4971	4856	4849	5048	4987	5043	5069	5045	5974	6242
thermal energy, Gcal	5664	6166	5234	5109	5150	5235	5838	6328	8357	5220
Specific fuel consumption for generation of electric energy, 10^3 kWh	0.366	0.363	0.364	0.358	0.363	0.365	0.367	0.359	0.361	0.363
Specific fuel consumption for heat generation, Gcal	0.161	0.16	0.159	0,158	0,161	0,160	0,161	0,159	0,159	0,160
Methanol, tons	1743	1825	1859	2004	2099	2151	2186	2157	2269	2258
Gasoline, tons	288	450	273	306	362	368	316	416	199	266
Diesel, tons	1093	1368	1222	1102	997	1237	1064	1355	982	1021

Method of calculation of EROCS is as follows. The first step is to convert all types of energy consumption to cubic meters using the conversion rates. The second step is to calculate EROCS according to Equation (6). The third step is to determine the numerator of the formula, taking the amount of implemented energy equivalent of gas and condensate. The fourth step is to determine the denominator of the formula, that is the sum of the energy equivalent the primary energy expended in the production of electric and heat power, as well as the energy equivalent of methanol, gasoline, and diesel fuel. The fifth step is to calculate the net costs of the primary energy source for the production of electricity and heat by multiplying the energy expended in specific fuel consumption for generation of the corresponding type of energy.

3. Data about ROFA and EROFA Calculation

To calculate ROFA required data of net profit and the cost of fixed assets. The information can be found in open financial records as follows (Table S3).

Table S3. ROFA data given for calculation.

Year	2005	2006	2007	2008	2009
Net profit, thousand rubles	−318,169	−73,208	−172,097	−45,481	191,214
The cost of fixed assets, thousand rubles	1,897,899	1,288,052	1,224,617	963,813	2,947,083
Year	2010	2011	2012	2013	2014
Net profit, thousand rubles	619,883	804,024	1,070,799	1,330,515	1,501,432
The cost of fixed assets, thousand rubles	2,974,220	2,812,073	4,452,899	5,091,660	6,768,858

The EROFA calculation is made using the energy equivalent of each fixed assets object. The energy equivalent should produce the same operations as a monetary value. Additionally, the operation of the revaluation is under the energy equivalent. This means that production of each object had spent a certain amount of energy and materials. Therefore, to overestimate the energy equivalent is impossible. However, determination on the energy equivalent of property, plant, and equipment is a large independent scientific problem. For example, in order to determining the energy equivalent of a tractor, we should know the energy costs on the entire chain from mining ore and smelting steel to the energy consumption for parts and final assembly production. These works were carried out earlier. Therefore, we will make a simplified calculation using only the energy equivalent of major structural materials—steel, cement, and aluminum—in this paper. The EROFA calculation of the accrued depreciation is not difficult given the energy equivalent of each object. When we assign not only the value but also the energy, the calculation EROFA can be done as easily as ROFA. However, currently this is not done. Information about the movement of assets individually is confidential and usually is not provided in open sources. Therefore, it is only possible to calculate one value for EROFA (at the end of 2014). Data for calculating EROFA is presented in Table S4. We have information on accumulated depreciation for each facility. Therefore, the depreciation will be credited with the average for all objects based on a percentage of the initial and residual value of the fixed assets provided in the financial annual report. During the reporting period objects of fixed assets as the following operations are generally made: (1) acquisition and registration, (2) leaving and removal from balance, (3) depreciation charge, and (4) revaluation. As a result, the total value of cost of fixed assets is calculated at the end of the period.

Table S4. Assets of JSC "YATEC" at the end of 2014 to calculate EROFA.

Fixed assets	unit	Number	Steel,t	Cement,t	Aluminium,t
The total capacity of power plants	kwt	18655	424		
The number of power transformers	pieces	36	46.8		
The number of electric motors installed	pieces	380	30.4		
The length of the OTL, in total	km.	105.6			
OTL - *0.4 kWt*	km	9.5			1.3
OTL – *6 kWt*	km	48.5			13.1
OTL – *35 kWt*	km	47			15.7
The number of boilers at the end of the year	pieces	4			
Total power of boilers	Gkal/hour	23.1			
The number of installed boilers	pieces	18	48.6		
The length of heat networks in 2-pipe	km	7.52			
diameter up to 200 mm	km	6.6	204.6		
diameter from 200 mm to 400 mm	km	0.92	84.64		
automobile transport					
Tractor T-130	pieces	15	225		
Trucks	pieces	51	510		
Cars	pieces	43	60		
Capl facilities	sq.m	8500			
The consumption of steel for the cap space	t		306		
The consumption of cement in cap space	t			3060	
The production casing	t		22464		
Technological plumes	t		5126		
Collectors	t		5054		
UKPG (2units)	t		1600		
Capacitive Park	t		2600		
Cement	t			43250	
Installation for processing of condensate	t		3300		

4. Data about the Specific Cost and Energy Efficiency of Gas Extraction

Generally, for the raising of hydrocarbons on a surface, the pump, compressor equipment, and auxiliary materials is used a different look. These expenses, including power, depend on geological conditions, quality of stocks, and energy efficiency of the equipment. In a case with the considered fields of a condition of a bedding allow for the conduction of gas production and its transportation through the main pipeline using only sheeted energy without the compressor and pump equipment. However, methanol is filled in to prevent hydrate formation in wells. In fact, it is the only essential look which is made directly on the mouth of a well. Data that are necessary for determining the specific cost of extraction of gas and condensate are as follows: (1) the volume of the extracted gas, and (2) expenses on acquisition and delivery of methanol, Table S5.

Table S5. Volumes of realization of gas and expenses on acquisitions and delivery of methanol.

Year	2005	2006	2007	2008	2009
Gas sales, million m^3	1296	1374	1381	1512	1614
Methanol, t	1743	1825	1859	2004	2099
Methanol, acquisition costs and delivery, th	22286	25855	32150	40697	37916
Year	2010	2011	2012	2013	2014
Gas sales, million m^3	1607	1590	1664	1685	1702
Methanol, t	2151	2186	2157	2269	2258
Methanol, acquisition costs and delivery, th	34586	37768	42551	51093	53492

Calculation of an indicator is made via the division of expenses on hydrocarbon extraction into volume of the realized gas. Calculation of energy efficiency of hydrocarbon extraction is made via a division of an energy equivalent of the realized gas into an energy equivalent of the used methanol.

5. Data about specific cost and energy efficiency of gas extraction and preparation

These indicators include costs of the mouth of a well plus costs of collecting and preparation of gas on special installations. Data for calculation of these indicators are as follows: (1) the volume of the extracted gas, (2) expenses on acquisition and delivery of methanol, and (3) energy consumption on complex preparation of gas. All necessary data are provided in Tables S5 and S6.

6. Data about specific capital expenses and energy efficiency of capital expenditure for exploration and production.

Data that are necessary for the indicator calculation as follows: (1) energy consumption and material costs on drilling of new wells, acquisition of the new equipment and buildings of new production objects; (2) energy consumption and costs of materials on carrying out search and prospecting works; and (3) energy consumption and material costs on workover and the equipment.

Large oil and gas companies continuously invest in searching of new fields in order to maintain and increase current production level. However, this situation in the Yakutsk fuel and energy company is a little different. It misses the opportunity to export gas outside due to the fact that the natural gas market in the Republic is limited. Therefore, currently the level of gas reserves is sufficient to meet consumption levels for decades. This means capital investment is minimal. Capital investment is limited to replacement of the equipment, overhaul of wells, the costs of the exploration works, and drilling of exploration wells on new license areas (Table S6).

Table S6. Material costs, energy consumption, and total capital costs of exploration and production of JSC Yakutsk fuel and energy company.

Name	2010	2011	2012	2013	2014
The 2-D seismic prospecting, km		200	100		100
Fuel, t		25	12		14
The 3-D seismic survey, km^2				300	
Fuel, t				23	
The drilling of wells, m				2850	2900
Steel, t				280	290
Cement, t				250	250
Fuel, t				380	390
Capital repair of wells, PCs	4	5	8	8	7
Steel, t	40	50	80	80	60
Fuel, t	40	50	70	70	60
The total cost, 10^6 rub	68.8	183.3	149.9	580.3	496.5