

# Assessment and prospectives of efficient energy consumption in the western energy region of the Republic of Sakha (Yakutia)

## Evaluación y perspectivas del consumo eficiente de energía en la región occidental de energía de la República de Sakha (Yakutia)

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#### ABSTRACT:

As a result of the research work "Assessment, the main trends in the natural and socio-economic status, human potential of the Western economic zone of the Republic of Sakha (Yakutia)", a part of the comprehensive research program under state contract N5327 of 08/02/2017, this paper presents a comparative assessment of the efficiency of electricity consumption in the context of settlements of the Western Economic Zone (WEZ) of the Republic of Sakha (Yakutia). The relevance of the study stems from the fact that not only natural but also cost indicators of consumption of fuel and energy resources are calculated for the first time. Proposals and recommendations for efficient production and consumption of fuel and energy resources in the settlements of the WEZ are developed. The study makes it possible to develop a fuel and energy balance of the republics. Based on the results of this study, it is necessary to regularly supplement and update the results of the basic fuel and energy balance of the Republic of Sakha (Yakutia) in the context of settlements in the regions of the WEZ. In recent years, relevant studies have not been carried out in the Republic of Sakha (Yakutia), especially in the context of each settlement and the main groups of consumers of electricity.

**Keywords:** energy resources, production, consumption, Western Economic Zone

#### RESUMEN:

Como resultado del trabajo de investigación "Evaluación, las principales tendencias en el estado natural y socioeconómico, el potencial humano de la zona económica occidental de la República de Sakha (Yakutia)", una parte del programa de investigación integral bajo el contrato estatal N5327 del 08/02/2017, este documento presenta una evaluación comparativa de la eficiencia del consumo de electricidad en el contexto de los asentamientos de la Zona Económica Occidental (ZEO) de la República de Sakha (Yakutia). La relevancia del estudio se deriva del hecho de que no solo se calculan por primera vez los indicadores naturales de consumo de combustible y recursos energéticos. Se desarrollan propuestas y recomendaciones para la producción y consumo eficientes de combustible y recursos energéticos en los asentamientos de la ZEO. El estudio permite desarrollar un balance de combustible y energía de las repúblicas. Según los resultados de este estudio, es necesario complementar y actualizar regularmente los resultados del balance básico de combustible y energía de la República de Sakha (Yakutia) en el contexto de los asentamientos en las regiones de la ZEO. En los últimos años, no se han realizado estudios relevantes en la República de Sakha (Yakutia), especialmente en el contexto de cada asentamiento y los principales grupos de consumidores de electricidad.

**Palabras clave:** recursos energéticos, producción, consumo, Zona Económica Occidental

## 1. Introduction

In order to define the Energy Strategy of the Republic of Sakha (Yakutia) for the period up to 2050, it is necessary to formulate the conditions for the development of the republic's fuel and energy complex and balance to the development of alternative and renewable energy in the WEZ, which can have a significant impact on economic, social and cultural processes in the republic. Until now, no relevant studies of the production and consumption of fuel and energy resources has been conducted with regard to development

of renewable types of energy to draw up a prospective fuel and energy balance of the Republic of Sakha (Yakutia)

In our study, the following analytical materials were used: The following analytical materials are used in our study: Energy Strategy of the Republic of Sakha (Yakutia) for the period up to 2030 (Petrov, 2005), Scheme for the integrated development of productive forces, transport and energy of the Republic of Sakha (Yakutia) up to 2020 (The Scheme for Integrated Development, 2006), Fuel and energy balance of the Republic of Sakha (Yakutia) Part. 1 (Petrov, 2005), Scheme and program for the development of the electric power industry of the Republic of Sakha (Yakutia) for 2017-2021 (The Scheme and Program for the Development), General Layout of Power Facilities Layout of Power Facilities (General Plan for Energy Facilities, 2017), Annual Reports of PJSC Yakutskenergo for 2011-2016, Annual Reports of Sakhaenergo JSC for 2011-2016, Official materials of the Ministry of Housing and Communal Services of the Republic of Sakha (Yakutia), Official materials of the Ministry of Industry and Geology of the Republic of Sakha (Yakutia), official materials of the state Committee on Pricing Policy of the Republics of Sakha (Yakutia), Scheme and Development Program of Development of the Energy Industry of the Republics of Sakha (Yakutia) 2017-2021, the Russian statistical yearbook data Rosstat etc.

The object of study is the natural resource potential, mining and processing industry in the WEZ. The purpose of the study is to:

- present an analysis of existing general and specific problems of power supply in the context of the zones of the WEZ;
- give scientifically based proposals and recommendations for the efficient consumption and production of electricity in the region's WEZ.

According to the goal, the following tasks were developed: to conduct a retrospective analysis of the consumption and production of fuel and energy resources in the context of settlements in the regions of the WEZ; evaluate the existing general and specific problems of power supply in the context of the zones of the WEZ; to develop relevant proposals and recommendations for the efficient consumption and production of fuel and energy resources in the areas of the Western economic zone of the Republic of Sakha (Yakutia).

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## 2. Methodology

The problem of conditions for effective long-term energy supply is not new for studying the world economy. For example, the problem of the efficiency of electric heating and the development of renewable energy sources of energy were central to previous studies by Elyakov, Koryagin, Pakhomov et al. (Elyakova and Koryagina, 2015; Elyakova et al., 2016; Petrov et al., 2010). This question is also presented in the studies of Mugway and Mortazavi - they consider the balance between demand and supply of energy, to be one of the problems facing politicians; In accordance with their study, the main goal of energy planning is to achieve a balance and energy model that can be used for supply and demand for the future planning of a country or region (Mougouei and Mortazavi, 2017); Nnaemeka and Boo - their article examines the point of view of effective energy management with demand-side strategic energy savings and the resource potential of renewable energy in Nigeria to ensure sustainable development (Nnaemeka and Boo, 2015); Kinoshita - It has been found that households reduce electricity consumption if their monthly electricity tariffs increase, and if they recognize the possibility of interruptions that can be effective in order to announce the possibility of interruptions or instability in the supply of households as a push (Kinoshita, 2017).

The research uses the following scientific methods: general scientific methods (systematic and historical method, analysis and synthesis method); specific scientific methods (research method, problem-chronological method); theoretical methods with subsequent analysis and generalization of results (statistical, observational and comparison, balance and empirical methods).

Statistical collections of the Russian Federation (2000–2016), analytical and static reports of municipal districts of the Republic of Sakha (Yakutia) (2000–2016), and the reports of PJSC Yakutskenergo and Sakhaenergo OJSC were used as information database for the development of fuel and energy balance.

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## 3. Results and discussion

All seven regions of the Western economic zone are included in the Western energy district, which consists of the industrial Mirny and Lensky regions, the Vilyui and Olekminsky agricultural regions are combined.

Until 2014, the Western energy district worked in isolation from other energy regions of the republic. In 2014, with the construction and commissioning of VL-220 kV Olekminsk- N. Kuranakh designed to supply electricity to ESPO consumers, the West Yakutian and South Yakutian energy districts (UES of the East) were electrically connected. Thus, the Western energy district has an electrical connection with the South Yakutian energy region and the UES of the East via a 220 kV transmission line.

The main source of power supply to consumers in the Western energy district is the Cascade of Vilyui HPP-1.2 of PJSC Yakutskenergo with an installed capacity of 680 MWh, Svetlinskaya HPP (OJSC Vilyuiskaya HPP-3), ALROSA PJSC. (Elyakova, 2015). 99.9% of consumers are covered by centralized power supply in the WEZ, and only 0.1% of Olekminsky district consumers receive electricity from decentralized energy sources (Elyakova et al., 2018).

The western energy district of the Republic of Sakha (Yakutia) includes a centralized (99.5%) and decentralized energy supply zone (0.5% to the settlements of Olekminsky district). Electricity supply to consumers from centralized sources (especially from hydroelectric power stations), when supplying electricity to a single grid of the power system, is considered the most reliable and efficient power supply system.

Currently, the largest consumers of electricity in the WEZ are enterprises operating in mining (57%), transport and communications 9.3%), production and distribution of electricity (7.7%) and the population (14%). The Western energy district has the highest energy consumption in Mirny district. Electricity consumption by major consumer groups in the settlements of the Western energy district is presented in table 1, the structure of electricity consumption is in table 2.

**Table 1**  
Electricity consumption by main consumer groups in the settlements of the Western energy district for 2000–2016, million kWh.

<b>Western energy district</b>	<b>2000</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2016 / 2000, в %</b>
Electricity consumption by industry, total	2519	1726	1656	1689	1573	1969	2467	2548	103,2
<b>including</b>									
- agriculture, hunting and forestry	164	19	41	12	11	10	10	9	90,0
- mining	1945	1064	881	870	736	1051	1407	1453	103,2
- manufacturing		70	98	102	96	87	93	95	102,1
- production and distribution of electricity		153	131	128	126	133	136	197	144,8
- building		9	7	7	6	6	6	11	183,3
- transport and communication	62	22	95	107	113	168	311	238	76,5
- other utilities and social services	17	51	64	60	53	52	33	34	103,0
- others	151	129	107	136	140	149	151	152	100,6
- population	180	209	232	269	291	314	320	357	111,6

Compiled by the authors based on data of PJSC Yakutskenergo (Annual reports of PJSC "Yakutskenergo" for 2011 -2016).

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**Table 2**  
Power consumption structure by main consumer groups of WEZ for 2000–2016, mln kWh

<b>Western energy district</b>	<b>2000</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2016 / 2000, %</b>
<b>Electricity consumption by type of economic activity, including</b>									
- agriculture, hunting and forestry	6,5	1,1	2,5	0,7	0,7	0,5	0,4	0,35	46

- mining	77,2	61,6	53,2	51,5	46,8	53,4	57,0	57,0	65
- manufacturing		4,1	5,9	6,0	6,1	4,4	3,8	3,7	128
- production and distribution of electricity		8,9	7,9	7,6	8,0	6,8	5,5	7,7	122
- building		0,5	0,4	0,4	0,4	0,3	0,2	0,4	125
- transport and communication	2,4	1,3	5,7	6,3	7,2	8,5	12,6	9,3	1038
- the provision of other utilities and social services	0,7	3,0	3,8	3,5	3,4	2,6	1,3	1,3	62
- other types of economic activity	6,0	7,5	6,5	8,1	8,9	7,6	6,1	6,0	111
- population	7,1	12,1	14,0	15,9	18,5	15,9	13,0	14,0	275

Compiled by the authors based on data of PJSC Yakutskenergo  
(Annual reports of PJSC "Yakutskenergo" for 2011 -2016)

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**Table 3**  
Electricity consumption by consumer groups  
in the Lensky district for 2012-2016

Consumers	2012			2016			2016/2012		
	Tariff	Volume	Revenue	Tariff	Volume	Revenue	Tariff	Volume	Revenue
	Rubles/ kWh	Million kWh	Thousand rubles.	Rubles/ kWh	Million kWh	Thousand rubles.	%	%	%
TOTAL	132226	549	4,15	325502	1650	5,07	246,17	300,46	122,05
Population, total	52806	131	2,49	51986	172	3,32	98,45	131,01	133,07
Budget, total	10918	53	4,85	9995	85	8,49	91,55	160,37	175,18
Enterprises of housing and utilities infrastructure	7040	33	4,75	23503	198	8,42	333,87	592,25	177,39
Other	61462	331	5,39	240018	1194	4,98	390,51	360,76	92,38
<b>Lensk</b>									
TOTAL	92277	387	4,19	283168	1380	4,87	306,87	357,18	116,40
Population, total	36443	91	2,51	36074	120	3,32	98,99	130,96	132,30
Budget, total	6486	31	4,86	5966	51	8,50	91,98	161,02	175,07
Enterprises of housing and utilities infrastructure	5680	27	4,75	18948	160	8,47	333,60	595,04	178,37

Other	43668	237	5,41	222180	1049	4,72	508,79	443,72	87,21
<b>Settlements of the Lensky district</b>									
Vitim	18681	82	4,39	18977	123	6,50	102	150	148,05
Peledui	13370	53	3,99	14759	90	6,10	110	169	152,97
Batamai	516	2	4,49	125	1	4,85	24	26	108,00
Bechencha	858	3	3,23	1103	4	3,97	129	158	122,70
Nuya	2833	9	2,99	1229	7	5,39	43	78	179,91
Ortho Nahara				609	3	5,29			
North Nuya	300	1	3,20	3982	32	8,05	1328	3345	251,82
Tolon	230	1	3,19						
Turukta	182	1	3,43						
Hamra	221	1	3,25						
Chamcha	348	1	3,29	467	2	4,89	134	199	148,53
Yaroslavsky	1330	6	4,28	267	2	6,21	20	29	145,20

Source: Summary data compiled by the authors on the basis of information from PJSC Yakutskenergo. (Annual reports of PJSC "Yakutskenergo" for 2011 -2016)

The largest consumers in the WEZ are AK ALROSA (PJSC), Transneftenergo LLC and Teploenergосervice JSC (Vilyui branch), which are shown in table 4.

**Table 4**  
Energy consumption in the WEZ in 2012 and 2016.

ZER	2012		2016		Growth rate 2016/2012, %	
	m. kWh	m. rub	m. kWh	m. rub		
Population, total	308	550	389	797	126	145
including Electric heating *	57	23	150	87	264	384
Budget, total	65	265	57	411	88	155
Federal budget	9	35	7	51	82	145
Republican budget	18	75	17	118	90	158
Local budget	38	155	33	241	88	156
Housing and communal services enterprises, including:	160	651	51	363	32	56
TES JSC (Vilyui branch)	126	513	116	785	92	153
Others, including:	1 161	4 869	1 328	7 985	114	164
PJSC AK ALROSA, total	961	3 944	723	4 664	75	118

Transneftenergo LLC total, including:	85	353	204	1 160	239	329
Oil pumping station -14	85	353	68	443	80	126
Oil pumping station -13			53	313		
Oil pumping station -12			49	184		
Oil pumping station -11			34	219		
Oil pumping station -15						
Oil pumping station -8.9						
Distribution network			1 586	10 690		
<b>TOTAL</b>	<b>1 695</b>	<b>6 335</b>	<b>1 825</b>	<b>9 556</b>	<b>108</b>	<b>151</b>

Compiled by the authors based on data of PJSC Yakutskenergo  
(Annual reports of PJSC "Yakutskenergo" for 2011 -2016)

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**Table 5**  
Electricity consumption by consumer groups  
in the Lensky district for 2012-2016

Consumers	2012			2016			2016/2012		
	Tariff	Volume	Revenue	Tariff	Volume	Revenue	Tariff	Volume	Revenue
	Rubles/ kWh	Million kWh	Thousand rubles	Rubles/ kWh	Million kWh	Thousand rubles.	%	%	%
TOTAL	132226	549	4,15	325502	165	5,07	246,17	300,46	122,05
Population, total	52806	132	2,49	51986	172	3,32	98,45	131,01	133,07
Budget, total	10918	53	4,85	9995	85	8,49	91,55	160,37	175,18
Enterprises of housing and utilities infrastructure	7040	33	4,75	23503	198	8,42	333,87	592,25	177,39
Other	61462	331	5,39	240018	1194	4,98	390,51	360,76	92,38
Lensk									
TOTAL	92277	386	4,19	283168	1380	4,87	306,87	357,18	116,40
Population, total	36443	92	2,51	36074	120	3,32	98,99	130,96	132,30
Budget, total	6486	31	4,86	5966	51	8,50	91,98	161,02	175,07
Enterprises of housing and utilities infrastructure	5680	27	4,75	18948	160	8,47	333,60	595,04	178,37

Other	43668	236	5,41	222180	1049	4,72	508,79	443,72	87,21
<b>Settlements of the Lensky district</b>									
Vitim	18681	82	4,39	18977	124	6,50	102	150	148,05
Peledui	13370	53	3,99	14759	90	6,10	110	169	152,97
Batamai	516	2	4,49	125	1	4,85	24	26	108,00
Bechencha	858	3	3,23	1103	4	3,97	129	158	122,70
Nuya	2833	8	2,99	1229	7	5,39	43	78	179,91
Ortho Nahara				609	3	5,29			
North Nuya	300	1	3,20	3982	32	8,05	1328	3345	251,82
Tolon	230	1	3,19						
Turukta	182	1	3,43						
Hamra	221	1	3,25						
Chamcha	348	1	3,29	467	2	4,89	134	199	148,53
Yaroslavsky	1330	6	4,28	267	2	6,21	20	29	145,20

Source: Summary data compiled by the authors on the basis of information from PJSC Yakutskenergo.(Annual reports of PJSC "Yakutskenergo" for 2011 -2016)

An analysis of the dynamics of the power consumption structure from PJSC Yakutskenergo and Vilyui HES-3 of ALROSA PJSC for WEZ for individual consumer groups in particular shows a significant increase in total consumption (by 50%), due to housing and communal services enterprises (by 50%), population (by 26%). At the same time consumption of other industrial consumers remained at the same level, while for budgetary consumers there was a decrease in consumption by 12%. During the study period, the average electricity tariffs in the region as a whole increased by 9%, including the largest growth (by 77 and 82%) observed for housing and communal services enterprises and budget organizations and for other consumers (by 48%). Growth rates were lower for the population (by 14%). Electricity consumption in the whole of the WEZ and by district, including the main consumer groups for 2000–2016, million kWh is presented in table 6.

**Table 6**  
Electricity consumption in the WEZ by regions, including the main consumer groups in 2000–2016, million kWh.

Consumers	2012			2016			2016/2012		
	Volume	Revenue	Tariff	Volume	Revenue	Tariff	Volume	Revenue	Tariff
	Thousand kWh	Thousand rubles.	Rubles/ kWt	Thousand kWh	Thousand rubles.	Rubles/ kWt	%	%	%
<b>Western Economic Zone</b>									
TOTAL	1695	6508	3,84	2548,1	10673	4,2	150	164	109
Population	308	577	1,87	387	828	2,14	126	144	114
Budget	65	275	4,26	57	429	7,52	88	156	177
Enterprises of housing	37	160	4,28	56	439	7,78	151	275	182

and utilities infrastructure									
OTHER	1285	5497	4,28	1283	8139	6,34	100	148	148
<b>Verkhnevilyuysky district</b>									
TOTAL	23	71	3,08	26	122	4,74	111	171	154
Population, total	12	23	1,96	14	40	2,8	122	174	143
Budget, total	4	16	4,07	3	24	7,2	86	153	177
Enterprises of housing and utilities infrastructure	4	16	4,06	4	29	7,18	104	184	177
Other	4	17	4,65	4	29	7,22	112	174	155
Vilyui district									
TOTAL	30	102	3,38	35	179	5,2	115	177	154
Population, total	13	30	2,27	17	54	3,16	127	177	139
Budget, total	5	20	4,06	4	31	7,22	85	151	178
Enterprises of housing and utilities infrastructure	6	23	4,07	6	42	7,18	102	181	177
Other	6	27	4,66	7	53	7,22	124	192	155
Lensky district									
TOTAL	132	549	4,15	326	1649	5,07	246	301	122
Population, total	53	132	2,49	52	172	3,32	98	131	133
Budget, total	11	53	4,85	10	85	8,49	92	160	175
Enterprises of housing and utilities infrastructure enterprises	7	33	4,75	24	198	8,42	334	592	177
Other	61	331	5,39	240	1194	4,98	391	361	92
Mirny district									
TOTAL	1233	4875	3,96	1762	8822	5,00	143	181	126
Population, total	115	243	2,10	108	293	2,71	94	121	129
Budget, total	20	82	4,07	17	120	7,17	83	146	176



Enterprises of housing and utilities infrastructure	1	6	4,03	4	26	7,17	251	447	178
Other	1096	4544	4,15	1633	8383	6,43	83	129	155
<b>Nyurba district</b>									
TOTAL	62	170	2,76	87	280	3,2	141	164	116
Population, total	33	45	1,38	60	86	1,42	185	191	103
Budget, total	8	33	4,08	8	58	7,23	100	177	177
Enterprises of housing and utilities infrastructure	9	38	4,05	8	57	7,13	86	152	176
Other	12	55	4,66	11	78	7,26	92	142	156
<b>Olekminsky district</b>									
TOTAL	129	582	4,5	144	1039	7,24	111	179	161
Population, total	21	51	2,41	29	74	2,57	137	145	106
Budget, total	5	26	4,75	5	38	8,43	83	147	177
Enterprises of housing and utilities infrastructure	5	23	4,78	6	48	8,06	123	207	169
Other	98	482	4,92	104	879	8,43	106	182	171
<b>Suntar District</b>									
TOTAL	86	158	1,85	130	277	2,14	151	175	116
Population, total	61	52	0,86	106	108	1,02	174	207	119
Budget total	11	44	4,04	10	72	7,2	92	164	178
Enterprises of housing and utilities infrastructure	5	21	4,04	6	40	7,15	109	193	177
Other	9	41	4,64	8	57	7,21	89	139	156

Compiled by the authors based on data of PJSC Yakutskenergo  
(Annual reports of PJSC "Yakutskenergo" for 2011 -2016)

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**Table 7**  
Electricity consumption by consumer  
groups in Mirny district for 2012-2016

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Consumers	2012			2016			2016/2012		
	Volume	Revenue	Tariff	Volume	Revenue	Tariff	Volume	Revenue	Tariff
	Thousand kWh	Million rubles.	Rubles/kWt	Thousand kWh	Thousand rubles.	Rubles/kWt	%	%	
TOTAL	1232585	4875	3,96	1761515	8822	5,01	143	181	127
Population, total	115407	2428	2,10	108140	293	2,71	94	121	129
Budget, total	20210	824	4,07	16787	120	7,17	83	146	176
Enterprises of housing and utilities infrastructure	1428	8	4,03	3588	26	7,17	251	447	178
Other	1095540	4545	4,15	1633000	8383	5,13	149	184	124
<b>City of Mirny</b>									
TOTAL	792423	1996	2,52	1022056	4456	4,36	129	223	173
Population, total	61750	130	2,09	56266	161	2,87	91	125	137
Budget, total	9711	40	4,07	6708	48	7,17	69	122	176
Enterprises of housing and utilities infrastructure	1379	6	4,02	2484	18	7,17	180	321	178
Other	719583	1823	2,53	956598	4229	4,42	133	232	175
<b>Settlements of Mirny district</b>									
Chernyshevsky	127373	511	4,01	113509	751	6,62	89	147	165
Svetly	12610	46	3,61	11299	69	6,11	90	152	169
Udachnyi	463413	1858	4,01	414801	2579	6,22	90	139	155
Aikhal	258833	1029	3,97	127386	744	5,84	49	72	147
Almazny	16300	70	4,27	18546	116	6,28	114	167	147
Zarya	1323	5	3,73	1235	7	5,76	93	144	154
Arylakh	56432	228	4,04	44077	272	6,18	78	119	153
Suldyukar	1534	5	3,51	845	5	5,99	55	94	171
Taas Yuryakh	3637	14	3,90	7747	48	6,27	213	343	161
Berezovyi	43	0,1	3,90	62	0,1	2,73	143	100	70
Novyi	59	0,1	1,96	184	0,5	2,96	314	474	151

Compiled by the authors based on data of PJSC Yakutskenergo  
(Annual reports of PJSC "Yakutskenergo" for 2011 -2016).

The largest consumers of electricity in Mirny district are Mirny (58%) and Udachny (23.5%).

A retrospective analysis for the past 5 years of the electricity consumption in the Lensky district of the WEZ shows that it has grown significantly (2.5 times), including growth for individual consumer groups. For utilities industry the growth was 3.3 times (due to with the transfer of housing from enterprises to the balance of municipalities), while the population and budgetary consumers experienced a decrease in consumption by 1.5-8.5%, respectively. Over this period, there was an increase in average electricity tariffs in the district (by 22%), including 75-77% increase for budgetary organizations and housing and communal

services, 33% increase for the population, while average tariffs for other consumers decreased by 8% (table 8).

**Table 8**  
Electricity consumption by consumer groups  
in the Lensky district for 2012-2016

Consumers	2012			2016			2016/2012		
	Tariff	Volume	Revenue	Tariff	Volume	Revenue	Tariff	Volume	Revenue
	Rubles/ kWt	Million kWh	Thousand rubles.	Rubles/ kWt	Million kWh	Thousand rubles.	%	%	%
TOTAL	132226	549	4,15	325502	1650	5,07	246,17	300,46	122,05
Population, total	52806	132	2,49	51986	172	3,32	98,45	131,01	133,07
Budget, total	10918	53	4,85	9995	85	8,49	91,55	160,37	175,18
Enterprises of housing and utilities infrastructure	7040	33	4,75	23503	198	8,42	333,87	592,25	177,39
Other	61462	331	5,39	240018	1194	4,98	390,51	360,76	92,38
<b>Lensk</b>									
TOTAL	92277	387	4,19	283168	1	4,87	306,87	357,18	116,40
Population, total	36443	91	2,51	36074	120	3,32	98,99	130,96	132,30
Budget, total	6486	31	4,86	5966	51	8,50	91,98	161,02	175,07
Enterprises of housing and utilities infrastructure	5680	27	4,75	18948	1601	8,47	333,60	595,04	178,37
Other	43668	236	5,41	222180	1049	4,72	508,79	443,72	87,21
<b>Settlements of the Lensky district</b>									
Vitim	18681	82	4,39	18977	123	6,50	102	150	148,05
Peledui	13370	53	3,99	14759	90	6,10	110	169	152,97
Batamai	516	2	4,49	125	1	4,85	24	26	108,00
Bechencha	858	3	3,23	1103	4	3,97	129	158	122,70
Nuya	2833	8	2,99	1229	7	5,39	43	78	179,91
Ortho Nahara				609	3	5,29			
North Nuya	300	1	3,20	3982	32	8,05	1328	3345	251,82
Tolon	230	1	3,19						
Turukta	182	1	3,43						

Hamra	221	1	3,25						
Chamcha	348	1	3,29	467	2	4,89	134	199	148,53
Yaroslavsky	1330	6	4,28	267	1	6,21	20	29	145,20

Source: Summary data compiled by the authors on the basis of information from PJSC Yakutskenergo (Annual reports of PJSC "Yakutskenergo" for 2011 -2016)

The largest consumers of electricity in the Lensky district are the city of Lensk (87%) and the village of Vitim (5.8%).

In 2016, compared to 2012, total electricity consumption in the Olekminsky district of the WEZ increased by 110% due to utilities infrastructure (123%, due to transfer of housing stock from enterprises to the balance of municipalities), other consumers (106%), and population (137%), while budget consumers had a 17% reduction in consumption. Over this period, there was an increase in average electricity tariffs in the district by 61%, including 77% increase for budget organizations, 69% for utilities infrastructure, and 6% for the population (table 9).

**Table 9**  
Electricity consumption by consumer groups in Olekminsky district for 2012-2016

Consumers	2012			2016			2016/2012		
	Tariff	Volume	Revenue	Tariff	Volume	Revenue	Tariff	Volume	Revenue
	Rubles/ kWh	Thousand kWh	Thousand rubles.	Rubles/ kWh	Thousand kWh	Thousand rubles.	Rubles/ kWh	Thousand kWh	%
TOTAL	129371	582181	4,50	143557	1039178	7,24	111	178	161
Population, total	21109	50946	2,41	28843	74009	2,57	137	145	106
Budget, total	5448	25903	4,75	4512	38018	8,43	83	147	177
Housing and communal services enterprises	4872	23274	4,78	5969	48138	8,06	123	207	169
Other	97942	482058	4,92	104232	879013	8,43	106	182	171
<b>Olekminsk and nearby villages</b>									
TOTAL	116976	545633	4,66	121918	969945	7,96	104	178	171
Population, total	10764	22892	2,13	11781	36321	3,08	109	159	145
Budget, total	4183	20754	4,96	2858	27023	9,45	68	130	191
Housing and communal services enterprises	4422	21467	4,86	5668	46056	8,13	128	215	167
Other	97608	480520	4,92	101611	860544	8,47	104	179	172
<b>Settlements of Olekminsky district</b>									
Sakhaenergo, including	4273	10752	2,52	2082	9218	4,43	49	86	176

Beating Kuel	118	255	2,16	35	185	5,24	30	73	243
Daban	317	719	2,27	77	362	4,68	24	50	206
Dapparay	580	1756	3,02	468	1962	4,19	81	112	139
Delgay	62	259	4,16	169	774	4,58	271	298	110
Innyakh	93	203	2,19	46	157	3,40	50	77	155
Kudu Kuel	182	394	2,16	75	271	3,62	41	69	167
Malykan	100	209	2,10	48	188	3,91	48	90	186
Marha	165	351	2,12	76	292	3,83	46	83	180
Macha	297	698	2,35	111	452	4,05	38	65	172
Snyahtakh	76	328	4,31	221	1108	5,01	290	338	116
Muddy	49	117	2,41	17	74	4,33	35	63	180
Tocco	958	2444	2,55	318	1509	4,75	33	62	186
Pull	289	663	2,29	85	356	4,22	29	54	184
Uritsky	232	492	2,12	72	312	4,32	31	63	203
Chapaev	754	1862	2,47	263	1215	4,62	35	65	187
Yakutskenergo	125098	571429	4,57	130875	1022919	7,82	105	179	171
including Olekminsk and nearby villages	116976	545633	4,66	121918	969945	7,96	104	178	171

Compiled by the authors based on data of PJSC Yakutskenergo  
(Annual reports of PJSC "Yakutskenergo" for 2011 -2016).

The largest consumer of electricity in the Olekminsky district is Olekminsk city (85.3%).

Analysis of the dynamics of electricity consumption in the Suntar district of ZEZ as a whole over the past 5 years shows that the volume of electricity consumption has increased significantly by 51%, including for certain groups of consumers: utilities growth index was 1.1 times (due to the transfer of housing from enterprises to the balance of municipalities), the population by 1.8 times, budget and other consumers, at the same time there was a reduction in consumption by 8-11%, respectively. During this period, there is an increase in average electricity tariffs in the whole district by 16%, including 77-78% - for utilities and budget organizations, 56% - for other consumers, 18% - for the population (table 10).

**Table 10**  
Electricity consumption by consumer groups  
in the Suntar district for 2012-2016

Consumers	2012			2016			2016/2012		
	Volume	Revenue	Tariff	Volume	Revenue	Tariff	Volume	Revenue	Tariff
	ThousandkWh	Thousand rubles.	Rubles/kWh	ThousandkWh	Thousand rubles.	Rubles/kWh	%	%	%
Total amount	85716	158267	1,85	129609	277368	2,14	151	175	116
Population, total	60844	52496	0,86	106132	108497	1,02	174	207	118
Budget, total	10947	44202	4,04	10067	72479	7,20	92	164	178

Enterprises of housing and utilities infrastructure	5071	20510	4,04	5525	39507	7,15	109	193	177
Others	8853	41059	4,64	7885	56885	7,21	89	139	156
<b>Suntar</b>									
Population, total	30800	25053	0,81	50230	51885	1,03	163	207	127
Budget, total	3286	13358	4,07	2809	20300	7,23	85	152	178
Enterprises of housing and utilities infrastructure	2158	8711	4,04	2932	20853	7,11	136	239	176
Population, total	4782	22182	4,64	4287	30922	7,21	90	139	156
Total	41026	69304	1,69	60258	123960	2,06	147	179	122
<b>Settlements in the Suntarsky district</b>									
Allaga	1569	2219	1,41	1825	4575	2,51	116	206	177
Arylakh	2476	4438	1,79	2284	6266	2,74	92	141	153
Arylakh(Gharkhan)	1569	2219	1,41	1943	3546	1,83	124	160	129
Ilimniir	632	912	1,44	1545	2321	1,50	244	255	104
Kempendyai	2290	4110	1,79	2727	7632	2,80	119	186	156
Krestyakh	3838	7210	1,88	4610	9580	2,08	120	133	111
Kuokunu	1530	3078	2,01	2325	5835	2,51	152	190	125
Kutana	1662	3277	1,97	4086	6891	1,69	246	210	86
Kyukei	760	1841	2,42	1094	3358	3,07	144	182	127
Kyundeya	1257	2445	1,94	3075	5543	1,80	245	227	93
Mar-keol	690	1391	2,02	1502	2774	1,85	218	199	92
Nakhara	353	878	2,49	550	1094	1,99	156	125	80
Sardanga	2650	6175	2,33	3870	7529	1,95	146	122	83
Agdary	1381	1720	1,24	1998	3227	1,62	145	188	130
Toibikhoi	9162	15878	1,73	12375	26256	2,12	135	165	122
Tolon	172	518	3,01	330	1032	3,13	192	199	104
Tuoidakh	458	1208	2,64	1049	3020	2,88	229	250	109
Tenke	705	1546	2,19	946	3103	3,28	134	201	150
Tyubei	643	1239	1,93	1185	2496	2,11	184	201	109
Ustie	757	1810	2,39	1091	3250	2,98	144	180	125
Uhun-Keol	404	1379	3,42	2984	3630	1,22	739	263	

									36
Khordogoi	1152	2807	2,44	3107	8154	2,62	270	290	108
Khoro	467	1246	2,67	1163	1949	1,68	249	156	63
Sheya	3036	9004	2,97	3700	15664	4,23	122	174	143
Yguatta	103	230	2,22	107	155	1,45	104	68	65
Elgyai	4969	10179	2,05	7881	14528	1,84	159	143	90
Neruktyai	2,48	4,79	1,93	0	0				

Source: Summary compiled by the authors based on the information of PJSC "Yakutskenergo» (Annual reports of PJSC "Yakutskenergo" for 2011 -2016).

The largest consumer of electricity in the Suntarsky district is Suntar (46.5%).

The analysis of the dynamics of electricity consumption in the Nyurbinsky district of WEZ over the past 5 years shows that the electricity consumption increased significantly by 41%, mainly due to the growth of consumption by population for 85% in the same time, budgetary institutions consumption remained unchanged, and the indices of housing and utilities infrastructure (HUI) companies decline for 14% and other consumers for 9%. During this period, there is an increase in average electricity tariffs in the whole district by 16%, including 77-78% - for HUI companies and budget organizations, 56% – for other consumers, 3% - for the population (table 11).

**Table 11**  
Electricity Consumption by consumer groups  
in the Nyurbinsky district for 2012-2016

Consumers	2012			2016			2016/2012		
	Volume	Revenue	Tariff	Volume	Revenue	Tariff	Volume	Revenue	Tariff
	ThousandkWh	Thousand rubles.	Rubles/kWh	Thousand kWh	Thousand rubles.	kWh	%	%	%
Total amount	61730	170419	2,76	87313	279556	3,20	141	164	116
Population, total	32621	45077	1,38	60474	86036	1,42	185	191	103
Budget, total	8078	32955	4,08	8082	58469	7,23	100	177	177
Enterprises of housing and utilities infrastructure	9296	37644	4,05	8024	57175	7,13	86	152	176
Others	11736	54743	4,66	10733	77876	7,26	91	142	156
<b>Nyurba</b>									
Population, total	18741	27327	1,46	36757	54495	1,48	196	199	102
Budget, total	4770	19493	4,09	4657	34077	7,32	98	175	179
Enterprises of housing and utilities infrastructure	5666	22842	4,03	5407	38444	7,11	95	168	176
Others	9852	44822	4,55	8376	61076	7,29	85	136	160

Total	39028	114484	2,93	55197	188092	3,41	141	164	116
<b>Settlements in the Nyurbinsky district</b>									
Akana	1121	2164	1,93	1572	3654	2,32	140	169	120
Antonovka	7390	16387	2,22	15553	32145	2,07	210	196	93
Bysyttakh	494	1436	2,91	673	3195	4,74	136	222	163
Dikimde	376	1037	2,76	518	2010	3,88	138	194	141
Gharkhan	751	1602	2,13	1594	4417	2,77	212	276	130
Kirov	374	1255	3,36	738	2125	2,88	197	169	86
Mar	2168	5728	2,64	3076	7453	2,42	142	130	92
Neftebaza	378	1347	3,56	289	1663	5,76	76	123	162
Nyurbachan	1175	3399	2,89	1512	4899	3,24	129	144	112
Engoldja	631	1839	2,92	1196	3309	2,77	190	180	95
Ynakhstyt	881	2061	2,34	2147	4008	1,87	244	194	80
Chukar	923	2661	2,88	1277	4229	3,31	138	159	115
Chappanda	1399	4126	2,95	3049	7054	2,31	218	171	78
Khatyn-Sysy	1289	2472	1,92	2675	5507	2,06	207	223	107
Khaty	659	1950	2,96	596	2406	4,03	90	123	136
Syule	556	1619	2,91	864	3160	3,66	155	195	126
Saiylyk	1250	4203	3,36	954	4223	4,43	76	100	132
Malykai	2223	6064	2,73	2082	8096	3,89	94	134	143
Kyundede	5710	9880	1,73	6827	18690	2,74	120	189	158
Edei	342	1092	3,20	476	1367	2,87	139	125	90

Source: Summary compiled by the authors based on the information of PJSC "Yakutskenergo». (Annual reports of PJSC "Yakutskenergo" for 2011 -2016)

The largest consumers of electricity in the Nyurbinsky district are Nyurba (41.4%) and Antonovka (17.2%). The analysis of the electricity consumption dynamics in the Verhneviljujsky district of WEZ over the past 5 years shows that the electricity consumption increased significantly by 51%, including for separate groups of consumers: the HUI companies and other consumers had the growth index for 1.1 times, the population for 1.2 times, at the same time the budgetary organizations reduced the electricity consumption by 14%. During this period, there is an increase in average electricity tariffs in the whole district by 54%, including 77% – for HUI companies and budget organizations, 55% – for other consumers, 43% - for the population (table 12).

**Table 12**  
Electricity Consumption by consumer groups  
in Verhneviljujsky district for 2012-2016.

Consumers	2012			2016			2016/2012		
	Volume	Revenue	Tariff	Volume	Revenue	Tariff	Volume	Revenue	Tariff





Tamalakan	489	1354	2,77	428	2118	4,95	87	156	179
Khatbalakh	454	1402	3,09	451	2342	5,20	99	167	168
Orget	548	1670	3,05	491	2439	4,96	90	146	163
Byrakan	602	1117	1,86	266	1393	5,23	44	125	282
Kharuyalakh	755	2021	2,68	632	3115	4,93	84	154	184
Andreevsky	374	1583	4,23	611	4424	7,24	163	280	171

Source: Summary compiled by authors based on the information of JSC "Yakutskenergo»  
(Annual reports of PJSC "Yakutskenergo" for 2011 -2016).

The largest consumer of electricity in the Verkhnevilyuysky district is Verkhnevilyuysk (33.3 per cent).

The analysis of the electricity consumption dynamics in the Viliuysky district of WEZ over the past 5 years shows that the electricity consumption significantly increased by 27%, including for separate groups of consumers: the HUI companies had the growth index for 1.02 times, other consumers - 1.24 times, the population - 1.27 times at the same time, budgetary institutions reduced the electricity consumption by 15%. During this period, there is an increase in average electricity tariffs in the whole district by 39%, including 76-78% - for HUI companies and budget organizations, 55% - for other consumers, 39% - for the population (table 13).

**Table 13**  
Electricity Consumption by consumer groups  
in the Vilyuysky district for 2012-2016

Consumers	2012			2016			2016/2012		
	Volume	Revenue	Tariff	Volume	Revenue	Tariff	Volume	Revenue	Tariff
	Thousand kWhe	Thousand rubles.	Rubles/kWhe	Thousand kWhe	Thousand rubles.	Rubles/kWhe	%	%	%
Population, total	13416	30484	2,27	17087	53938	3,16	127	177	139
Budget, total	5033	20433	4,06	4263	30768	7,22	85	151	178
Enterprises of housing and utilities infrastructure	5710	23229	4,07	5840	41928	7,18	102	181	176
Others	5897	27454	4,66	7318	52831	7,22	124	192	155
Total	30056	101600	3,38	34508	179465	5,20	115	177	154
<b>Vilyuysk</b>									
Population, total	6988	17755	2,54	8574	29649	3,46	123	167	136
Budget, total	2914	11829	4,06	2431	17550	7,22	83	148	178
Enterprises of housing and utilities infrastructure	3085	12588	4,08	3023	21679	7,17	98	172	176
Others	4203	19525	4,65	4267	31986	7,50	102	164	161
Total	16178	58788	3,63	18294	100865	5,51	113	172	152

<b>Settlements in the Vilyuysky district</b>									
Balagatchy	735	2416	3,29	998	4612	4,62	136	191	140
Betung	337	938	2,78	459	2326	5,07	136	248	182
Ekundu	276	831	3,01	312	1609	5,16	113	194	172
Ilbenge	794	2323	2,93	973	5320	5,47	123	229	187
Kyunde	186	573	3,09	192	989	5,14	104	173	167
Kyrova	393	1255	3,19	485	2287	4,72	123	182	148
Kyubeinde	386	1109	2,87	349	1623	4,65	90	146	162
Kyulekyan	410	1168	2,85	595	2195	3,69	145	188	130
Lekechen	384	1108	2,89	231	1041	4,50	60	94	156
Satagai	642	1855	2,89	564	2909	5,15	88	157	178
Sosnovka	408	1441	3,53	410	2491	6,07	100	173	172
Starovatova	124	512	4,13	116	839	7,25	93	164	176
Syudybyl	777	2551	3,28	833	4519	5,43	107	177	165
Tasagar	374	1038	2,78	495	2301	4,64	133	222	167
Terbyas	488	1411	2,89	460	2238	4,86	94	159	168
Tosu	944	2751	2,92	1347	4809	3,57	143	175	122
Tympy	575	1848	3,22	636	3198	5,03	111	173	156
Usun	475	1355	2,85	499	2193	4,40	105	162	154
Khampa	912	3437	3,77	1504	8560	5,69	165	249	151
Chai	430	1350	3,14	450	2399	5,33	105	178	170
Chineke	510	1763	3,46	1275	6356	4,99	250	361	144
Ebya	638	1919	3,01	1230	3974	3,23	193	207	107
Arylakh	94	350	3,73	121	753	6,24	129	215	167
Bagadya	125	439	3,52	167	905	5,44	133	206	154
Mastakh	405	1382	3,41	533	2935	5,51	132	212	161
Saiylyk	1045	2776	2,66	980	5219	5,33	94	188	200

Source: Summary compiled by authors based on the information of JSC "Yakutskenergo»  
(Annual reports of PJSC "Yakutskenergo" for 2011 -2016)

The largest consumer of electricity in the Vilyuysky district is Vilyuysk (50.2%).

The analysis of the electricity consumption dynamics in the Viliuisky district of WEZ over the past 5 years shows that the electricity consumption significantly increased by 27%, including for separate groups of consumers: the HUI companies had the growth index for 1.02 times, other consumers - 1.24 times, the

population - 1.27 times at the same time, budgetary institutions reduced the electricity consumption by 15%. During this period, there is an increase in average electricity tariffs in the whole district by 39%, including 76-78% - for HUI companies and budget organizations, 55% - for other consumers, 39% - for the population (table 12).

The analysis of the electricity consumption dynamics structure by PJSC "Yakutskenergo", Vilyuiskaya Hydroelectric generating station-3 (HGS-3) and SC ALROSA (PJSC) in the whole WEZ and in the different groups of consumers shows that there has been a significant increase in the electricity consumption by 50%, including the HUI companies by 51%, population by 26%, the volumes on other industrial consumers remained at the same level. At the same time, there is a decrease on electricity consumption of the budget consumers by 12%.

During the study period, average electricity tariffs in the region as a whole increased by 9 %, including the highest growth (by 77 and 82%) is observed for utilities and budget organizations, for other consumers by 48%. The growth rate was lower for the population (by 14%). The largest consumers of electricity in the Western energy district are the Mirninsky (69.1%) and the Lensky districts (12.8%).

In the Western energy district there are significant costs for imported fuel (coal, gas condensate, oil, diesel fuel) problems of its transportation and storage, difficulties of operation of boilers on organic fuel put forward the need to find alternative options for obtaining heat. One of the ways to solve the problem, primarily in relation to dispersed, small consumers is the elimination of uneconomical small boilers, as well as for heating the private residential sector, which uses firewood is the use of electric energy for heating purposes. The volumes of electricity used for electric heating of the private residential sector in seven districts of the WEZ for 2013-2016 are shown in table 3.8.17.

For 2013-2016 in the Western power district, the residential sector was transferred to the electric heating; the data of power consumption are presented in table 14.

**Table 14**  
Net supply of electricity for electric heating  
in the WEZ for 2013-2016., thousand kWh

District	2013	2014	2015	2016
Suntarsky district	52776	69701	78995	87182
Nyurbinsky district	19869	28283	31213	40139
Mirninsky district	1971	2242	2015	2320
Verkhnevilyuisky district		158	574	1775
Vilyuisky district		53	1184	1774
Olekminsky district		237	2408	10600
Lensky district		60	1684	6588

Source: Summary compiled by authors based on the information of JSC "Yakutskenergo»(Annual reports of PJSC "Yakutskenergo" for 2011 -2016)

Leaders in transfer to electric heating of private housing are Suntarsky and Nyurbinsky districts in connection with the construction of VL 220 kV to Suntar, the majority of the population transferred to the electric heating instead of using wood for heating furnace. Low dynamics of volumes of electric heating in other parts of the Vilyui group due to low transmission capacity of electric networks at 110 kV overhead line to Nyurba and further transmission to the Verkhnevilyuisky and Vilyuisky districts and gasification of settlements in the latter two areas. Potential of transfer to the electric heating in all seven districts are huge, with regard to its efficiency, environmental friendliness, operating, cheap electricity rates for electric heating and appropriateness for the operation of electric power enterprises in the Western energy district.

## 4. Conclusions

In our opinion, the construction of electric boilers and the transfer to electricity consumption of consumers is the most effective solution-providing reliable and high-quality electricity and heat supply to all groups of consumers of the Western energy district.

The transfer to electric heating in the districts of WEZ and hooking up to the centralized power supply of big oil and gas companies in the Lensky, Mirninsky districts, diamond mining enterprises - Nakynsky mining processing plant (MPP), JSC "ALROSA-Nyurba", SC "ALROSA (PJSC), as well as the construction of high-voltage lines VL-220 kV Suntar-Nyurba for Vilyuisky groups of districts would lead to reduction in

electricity tariff for electric boiler (need to build), save exhaustible fossil fuels like coal, crude oil, natural gas, gas condensate, to abandon residential heating with wood due to the transfer to electric heating. The increase in electricity consumption leads to a reduction in tariffs, which ultimately has a positive impact on the increase in incomes of enterprises and on improving the standard of living of the population.

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