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ScienceDirect

Energy Procedia 113 (2017) 121 – 126

Energy Procedia

International Scientific Conference "Environmental and Climate Technologies", CONECT 2016, 12–14 October 2016, Riga, Latvia

Assessment of regional energy system failure risks by use of wavelet transform

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Abstract

The majority of heat and electricity systems in the Russian regions nowadays are worn out due to implementation 37 years ago (on average). Thus it seems necessary to accurately assess the duration of their possible failure to reduce possibility of blackouts and to decide upon parallel energy supply system development which might include the shift to alternative sources of energy. Also mentioned assessment would allow predicting energy losses during delivery to the consumer.

The number of failures within production and delivery stages results in a decreased amount of energy delivered to the consumer. As losses occur, the amount of raw materials used by energy system remains unchanged or increase as a results of other production units' involvement, but the amount of energy received by the consumer decreases. In this paper we propose wavelet transform as a tool to predict the level of energy system malfunctioning risk, and thus switch to the other source of energy production/delivery to ensure increase in system's energy efficiency.

Peer-review under responsibility of the scientific committee of the International Scientific Conference "Environmental and Climate Technologies".

Keywords: energy; energy efficiency; wavelet transform

1. Introduction

Energy supply systems in contemporary Russia can be considered the core of regional infrastructure and one of the most important factors which influence economic development. At the same time starting in 1991 losses in Russian

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Peer-review under responsibility of the scientific committee of the International Scientific Conference "Environmental and Climate Technologies".
doi:10.1016/j.egypro.2017.04.033

electrical energy system had increased by 1.5, and at the same time only a few new generating complexes were empowered during this period of time [1]. This led to increased cost of electricity, and, due to aging of the power supply systems, to high number of blackouts. By 2012 industrial production in Russia had finally reached the country's starting point – 1991 production level – and continued growing even during 2014–2016 period, the economic crisis. Growing manufacturing puts extra pressure on electric energy supply system – and taking into account the average age of electric energy system equipment (32.9 years) – might lead to more frequent failures and even technogenic accidents.

For the purposes of this paper we have assessed the situation in Tatarstan republic electrical energy system. Tatarstan was chosen for the purposes of this study as a typical industrial region in the European part of Russia, which can be characterized with high share of industry in gross regional product. Tatarstan has total electricity generating capacity which exceeds regional demand for electricity; but besides one electricity producer all the capacity was created in Soviet Union and is exploited for at least 35 years by now. As a result of electrical energy system reform, the regional electricity supply system includes independent producers of electricity and heat, state-owner transmitting company, and engineering and service companies which are both private and state owned. At the current moment average level of equipment's depreciation is about 70 %, thus leading to growing number of failures, in some cases leaving a few municipalities without electricity for a day or more. Electrical energy system in this region needs serious modernization, and this is again a common situation for Russian regions, which led to the choice of Tatarstan.

Tatarstan Republic electricity generating system is currently operated as independent business units, and includes the following major elements [2]:

- Four electricity and heat producers, which operate in combined production cycle (JSC "Generation Company", JSC "TGC-16", LLC "Nizhnekamsk CHP" and JSC "TGC Urussinskaya GRES");
- Transmitting companies, including the biggest (both in terms of electrical networks length and the volume of transmitted electricity) – JSC "Network Company";
- JSC "Tatenergosbyt", the company which guarantees electricity supply in the region and operates according to legal requirements and limitations.

7 thermal power plants (CHP), 2 condensing power plants (GRES), and one hydroelectric power station are generating units within the regional energy system. The share of electricity generation by CHP and GRES is over 92 %. Distribution companies and power generation stations are presented in Table 1.

Table 1. The installed electric and heat capacity of power plants [1].

Power plant	Electric capacity, MW	Heat capacity, Gcal/h	Input year of the first unit
Umbrella company JSC "Generating Company", including	4995	6103	–
Kazan CHP-1	220	630	1933
Kazan CHP-2	190	851	1949
Naberezhnye Chelny CHP	1180	4092	1973
Yelabuga CHP	–	420	1994
Nizhnekamsk HPP	1205	–	1979
Zainsk GRES	2200	110	1963
Umbrella company JSC "TGC-16", including	1300	5643	–
Kazan CHP-3	420	1897	1968
Nizhnekamsk CHP/PTK-1	880	3746	1967
Umbrella company LLC "Nizhnekamsk CHP", including	380	1580	–
PTK-2	380	1580	1980
Umbrella company JSC "TGC Urussinskaya GRES", including	161	127	–
Urussinskaya GRES	161	127	1944