Multiobjective Analysis of Alternatives of Updating the Automated Dispatch Control of the Unified Power System of the Baltic States

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The existing Automated Dispatch Control System (ADCS) of Unified Electrical Power System (UPS) of Baltic States Estonia, Latvia and Lithuania is obsolete, its software inefficient, the Baltic Dispatch Centre (DC) and the National Dispatch Centre (NDC) are short of satisfactory both hardware and software for on-line control. This implies the necessity of important studies on modern dispatch control and automation, and the directions of updating. We consider the modernisation of computerized automated dispach control systems, using a multiobjective decision-making methods. The problem is to select the best alternative from a finite set of available alternatives. Each alternative is characterized by n criteria. Three methods of selecting the best alternative are realized in the decision support system used: Paired comparisons of alternatives, Pareto and Fuzzy. The paper includes the results of ranking of the alternatives of updating the ADCS of the UPS of the Baltic States using two methtods – Pareto and Fuzzy.

Key words: automated dispatch control system, national dispatch centre, unified electrical power system, supervisory control and data acquisition system, control area

1. INTRODUCTION

The existing Automated Dispatch Control Systems (ADCS) of the Baltic States, Estonia, Latvia and Lithuania, are obsolete. Its software and hardware are inadaptable to perform commercial account, data acquisition and verification functions. For this reason the ADCS have to be updated. The updating problems of the ADCS of the Power System (PS) have been analysed in detail in [1, 2]. The important theoretical issues of improving and extending the ADCS are considered in [3]. The updating of the ADCS of the PS is considered in this paper as a multiobjective optimal decision problem. The specific alternatives and wider survey of updating the ADCS of the PS by quantitative (*e.g.*, cost, pay-off period, emission quantity of SO_2 and NO_x, etc.) and verbal qualitative (different feasibilities, social effect, etc.) performance criteria are presented in this paper. Contradictions among the perfomance criteria in the presence of different alternatives are possible. Therefore, because of the incomplete information, it is reasonable to use the special decision support software (DSS) in ranking the alternatives. It must be noted that the ADCS have to cover all functions performed by Supervisory Control and Data Acquisition (SCADA), Energy Management System (EMS), Transmission Management System, and Distribution Management System.

2. THE UNIFIED POWER SYSTEM OF THE BALTIC STATES

The Unified Electrical Power System (UPS) of the Baltic States founded in 1991, is based on the bilateral agreements and is controlled by the common DC Baltic dispatch center. The basic Baltic bulk power transmission system consists of 330, 220 and 110 kV lines. The Baltic networks operate interconnected with the Russian and Newly Independent States (NIS) systems, the frequency regulation continuing to be the responsibility of the Central Dispatch Office in Moscow. Currently, the Baltic countries are not connected to any western power system. The Estonia–Finland submarine cable and Poland–Lithuania AC/DC overhead connections will be built in future.

The dispatch centers in the Baltic States have four level hierarchies. The DC Baltic Ltd. Control center is at the highest level. The main responsibilities of DC Baltic are: 1) dispatching the entire 330 kV network between the Baltic States and with the neighboring UPS of Russia and UPS of Belorus; 2) planning and dispatching a power balance for the Baltic power systems on daily, weekly, monthly and yearly basis; 3) ensuring the reliability of the entire 330 kV network under agreed criteria; 4) defining and allocating reserve requirements; 5) providing a reactive power balance and voltage control of the 330 kV network; 6) dispatching under emergency conditions; 7) coordinating maintenance schedules of the major generating units, transmission lines and relay protection; 8) performing 330 kV grid studies such as stability, short circuit, security and control; 9) determining the settings of relay protections and security devices of the 330 kV network.

At the second level are the National Dispatch Centers (NDCs) of Lithuania, Latvia and Estonia. The NDCs are responsible for generation and for the security of the national high voltage system. Also, they provide a reactive power balance and voltage control, coordinate maintenance schedules of the generating units, transmission lines and relay protection, etc.

The dispatch centers of the Regional Electrical Network Enterprises are at the third level, and the district dispatch centers are at the lowest hierarchy level of the dispatching system. These centers control 35 kV, 0.4–10 kV district networks, take part in maintenance schedules coordination, dispatching and analyzing emergency conditions.

Tables 1 and 2 present the main statistic data on the Unified Electrical Power System of the Baltic States.

3. ALTERNATIVES OF UPDATING THE ADCS OF THE UBPS

We consider the following alternatives of updating the ADCS of the Unified Baltic States Powner System (UBPS):

X_1 – the ADCS of the UBPS is updated by implementing a new modern Supervisory Control and Data Acquisition (SCADA) systems in the NDCs of all national power systems and in the Baltic DC, Automatic Control of Node Voltages and Reactive Power (AVRPC) systems in each national 330/220/110 kV network. The UBPS works without any Control Area (CA), the *n*-1 security requirements are not satisfied, the cost of ADCS updating is the least, the independence of the NDCs is the greatest, but there is not any competition between power plants because of Vertically Integrated Power Monopolies (VIPM). Any shortage of fast generation reserves could be compensated by the neigbouring state power systems. Transactions between interconnected utilities are negotiated by agreements for purchases or sales of energy for periods ranging from several days or months. Economic transactions may be automated through the Baltic DC;

X_2 – the ADCS of the UBPS is completely updated: the UBPS has a modern SCADA systems, the Automatic Generation and

Table 1. **Data on the UPS of the Baltic States**

Data	Lithuania	Latvia	Estonia	Total	Percent
1. Installed capacity (MW)	6473	2030	3313	11816	100
a) Nuclear Power Plant (NPP)	3000	–	–	3000	25
b) Combined Heat and Power Plant (CHP)	2567	520	3313	6400	54
c) Hydro Power Plant (HPP)	106	1510	–	1616	14
d) Pump Storage Power Plant (PSPP)	800	–	–	800	7
2. Production (TWh)	14	3.9	8.6	26.5	–
3. Consumption (TWh)	11.2	6.2	7.8	25.2	–
4. Export/Import (TWh)	2.8	–2.3	0.8	1.3	–
5. Population (mln)	3.700	2.557	1.530	7.787	–

Table 2. **The largest Power Plants in Baltic States**

Name	Country	Installed capacity, MW	Nominal capacity at the moment, MW
1. Ignalina NPP	Lithuania	3000	2600
2. Lithuania TPP	Lithuania	1800	1800
3. Eesti CHP	Estonia	1610	1600
4. Balti CHP	Estonia	1600	1434
5. Plavino HPP	Latvia	847.5	847.5
6. Kruonis PSPP	Lithuania	800	800
7. Iru CHP	Estonia	410	190
8. Ryga HPP	Latvia	402	400
9. Ryga CHP-2	Latvia	390	390
10. Vilnius CHP	Lithuania	384	365

Frequency Control (AGFC) system and AVRPC system in the main 330/220/110 kV network. The UBPS works as a CA. Every national PS works as separate CA inside the UBPS. This allows the automatic control of power flow interchanges between interconnected power systems inside the UBPS. An optimal generation control according to their characteristics is performed on the level of the NDCs or on the level of the power plants. The VIMP are restructured to the electricity generation, transmission and distribution companies in each national power system [4]. The n-1 security requirements are satisfied, the independence of the NDCs is a bit less than that of the alternative X1, a competition between power plants or between generating companies is possible. The cost of the ADCS updating is the greatest;

X_3 – the ADCS has a complete updating: the UBPS works as CA and it has modern SCADA systems on the Baltic DC and NDCs level, the AGFC and the AVRPC systems in the 330/220 kV networks. An optimal generation control according to their economic characteristics is performed on the Baltic DC level. The three Baltic States have formed one international grid pool of 330/220 kV networks. On this pool through Baltic DC all electricity producers and consumers are able to buy and to sell energy. The cost of ADCS updating is a bit less than updating the cost of the alternative X2. The n-1 security requirements are satisfied, the independence of the NDCs is the least, and a competition between power generating companies and power plants is possible.

4. CRITERIA FOR THE UTILITY ESTIMATION OF THE ADCS UPDATING

We introduce the following criteria for the ADCS updating utility estimation:

1. The cost $C_i \ (i=\overline{1.3})$ of updating ADCS.
2. The pay-off period of updating ADCS $T_i \ (i=\overline{1.3})$.
3. The emission quantity of SO_{2i} and NO_{xi} $Z_{3i} \ (i=\overline{1.3})$.
4. The possibility of AGFC and AVRPC $Z_{4i} \ (i=\overline{1.3})$; $0 \le Z_{4i} \le 1$.
5. The possibility of competition between generating utilities in the UBPS $Z_{5i} \ (i=\overline{1.3})$; $0 \le Z_{5i} \le 1$;
6. The level of independence of NDCs $Z_{6i} \ (i=\overline{1.3})$; $0 \le Z_{6i} \le 1$.
7. The possibility of connecting the UBPS into the interconnected power system UCPTE in West Europe $Z_{7i} \ (i=\overline{1.3})$; $0 \le Z_{7i} \le 1$;

It is reasonable to normalize the first three criteria C_i, T_i, SO_{2i} and NO_{xi} $(i=\overline{1.3})$; to be within the interval [0,1]. Then the utility functions $Z_{ij} \ (i=\overline{1.3};\ j=1.3)$ are determined in the following way:

$$Z_{ji}=\begin{cases}1, \text{ if } y_{ij} \le y_{ij}^{\min}; \\ \dfrac{y_{ij}-y_{ij}^{\max}}{y_{ij}^{\min}-y_{ij}^{\max}}, \text{ if } y_{ij}^{\min} < y_{ij} < y_{ij}^{\max}; \\ 0, \text{ if } y_{ij} \ge y_{ij}^{\max}. \end{cases}$$

$$\left(i=\overline{1.3};\ j=\overline{1.3}\right); \quad (1)$$

The importance of the normalized criteria, *i* utility functions are evaluated by their respective weight factors $W_j \in [0.1]$, subject to $\Sigma W_j = 1$. Experts determine the weight factors.

5. DECISION SUPPORT SOFTWARE

A multiobjective optimal decision problem is to select the best alternative X_i^* from a finite set of m alternatives $X_i=(i=\overline{1,m})$. Any alternative is characterized by *n* criteria. The criteria may be expressed by some values $y_{ij}=y_j\,(X_i)\,(i=\overline{1,m};\ j=\overline{1,n})$, where *m* is the number of alternatives, *n* is the number of criteria. Usually multiobjective decision support software (DSS) is used to solve a multiobjective problem with the help of experts – decision-makers (below called experts). The expert's generalized utility function U_i is used as additive [5]:

$$U_i=\sum_{j=1}^{n} W_j Z_j\left(y_{ij}\right), \quad \left(i=\overline{1,m}\right), \quad (2)$$

where W_j is the weight, and $Z_j\,(y_{ij})$ is the individual utility function of the *j*th criterion. The values of W_j and $Z_{ji} = Z_j\,(y_{ij})$, $(j=\overline{1,m};\ i=\overline{1,n})$ must be determined by an expert in the decision process. When the generalized utility functions U_i become known, the alternatives may be ranked according to the corresponding values $U_i \ (i=\overline{1,m})$.

The determination of the utility function in DSS may be divided into two procedures: 1) normalization of criteria values, *i.e.* determination of the values of individual utility functions $Z_{ji} = Z_j(y_{ij})$, $(j = \overline{1, m}; i = \overline{1, n})$; 2) determination of the weights $W_j \ (j = \overline{1, n})$ of utility functions.

The DSS includes three main components: a specialized data base, multicriteria decision making software, and man–computer interface. The system (experts and DSS) uses the following information from a specialized data base: names of alternatives, names and values of criteria, names of experts, intermediate dialogue actions of each expert, results of each expert, and integral results.

Three methods of increasing complexity are used in available DSS: Paired Comparisons of Alternatives, Pareto and Fuzzy [5].

Paired Comparisons of Alternatives. The paired comparison method is the simplest one from the user's point of view. The experts must only compare the alternatives by two at a time, and determine how important one alternative is regarding the other (more or less or equally important). However, we will not use this method, because of its low reliability. The values of utility functions are not directly involved in the paired comparison method, and alternatives may be ranked only on the basis of some description of alternatives or other information sources [5].

Pareto method. The Pareto method gives a Pareto subset of alternatives to the expert. The expert varies the weights $W_j \ (j = \overline{1, n})$ of utility functions $Z_{ji} = Z_j(y_{ij})$ according to the values of the generalized utility function:

$$U_i = \sum_{j=1}^{n} W_j Z_j(y_{ij}), \ \sum_{j=1}^{n} W_j = 1 \ (i = \overline{1, m}). \quad (3)$$

The values of generalized utility functions are normalized as follows:

$$d_i = \frac{U_i}{\max U_i} \quad (i = \overline{1, m}), \quad (4)$$

so that the largest normalized value $d_i^{\max} = 1$ and corresponds the best alternative.

Fuzzy method. The Fuzzy decision method is based on the features of fuzzy numbers with a triangular membership function [5–7]. Fuzzy numbers with triangular membership functions approximate the normalized criteria $\tilde{Z}_{ji}(j = \overline{1, n}; i = \overline{1, m})$. The procedure evaluates uncertainties experienced by the expert in the absence of exact values of the criteria. Such uncertainties are met in finding the values of both quantities and verbal criteria. The Fuzzy method is similar to the Pareto method, but the expert has the opportunity to doubt as to his opinion.

The Fuzzy method requires to determine the upper bound Z_{ji}^{u}, medium value Z_{ji}^{m}, and the lower bound Z_{ji}^{l} of each fuzzy value. The triangular $\tilde{Z}_{ji} = (Z_{ji}^{1}, Z_{ji}^{m}, Z_{ji}^{u})$ fuzzy number operation laws are used [6, 7]. Just as in the Pareto method, the expert must give the weights to all fuzzy utility functions $\tilde{Z}_{ji}$.

The best alternative may be found taking into account the information obtained from a single expert or from a group of experts. Just as in the Pareto method, the expert must give the weights W_j, $\sum W_j = 1$ of importance of all utility functions. The expert gives triangular fuzzy numbers $\tilde{Z}_{ji} = (Z_{ji}^{1}, Z_{ji}^{m}, Z_{ji}^{u}) \ (j = \overline{1, n}; i = \overline{1, m})$, where Z^{m}_{ji} are the mean estimates, Z^{1}_{ji} and Z^{u}_{ji} are the lower and the upper bounds. Every alternative is characterized by a fuzzy value:

$$\tilde{S}_i = \sum_{j=1}^{n} \left(Z_{ji}^{l}, Z_{ji}^{m}, Z_{ji}^{u}\right) * W_j \otimes \otimes \left[\sum_{i=1}^{m} \sum_{j=1}^{n} \left(Z_{ji}^{l}, Z_{ji}^{m}, Z_{ji}^{u}\right) * W_j\right]^{-1} \left(i = \overline{1, m}\right), \quad (5)$$

where $\otimes$ is a symbol of multiplication operation of fuzzy numbers. A scalar measure of the dominance of the alternative i over other ones is as follows:

$$d_i = \min_{\substack{l = \overline{1, n} \\ l \neq i}} V\left(\tilde{S}_i \geq \tilde{S}_l\right)\left(i = \overline{1, m}\right), \quad (6)$$

where $V(\tilde{S}_i \geq \tilde{S}_l)$ means the degree of possibility $(\tilde{S}_i \geq \tilde{S}_l)$. The detailed expressions of $V(\cdot\tilde{S}_i \geq \tilde{S}_l)$ are represented in [5, 6]. The optimal decision corresponds to the alternative with the $\max_{i=1, m} d_i = 1$. In the case with a group of q experts the normalized weights are represented as:

$$W_j^N = \frac{\frac{1}{q}\sum_{k=1}^{q} W_{jk}}{\sum_{j=1}^{n} \frac{1}{q}\sum_{k=1}^{q} W_{jk}} = \frac{\overline{W_j}}{\sum_{j=1}^{n} \overline{W_j}}, \ \left(j = \overline{1, n}\right), \quad (7)$$

where W_{jk} is the estimate of the jth weight of the jth utility function defined by an expert, W_j is the average weight. The ith alternative is characterized by the following fuzzy expressions:

$$\tilde{S}_i = \sum_{j=1}^{n} \tilde{Z}_{ji} W_j^N \otimes \left[\sum_{i=1}^{m} \sum_{j=1}^{n} \tilde{Z}_{ji} W_j^N \right]^{-1},$$

$$\left(i=\overline{1,m}\right); \tag{8}$$

$$\tilde{Z}_{ji} = \left(\overline{Z}^{l}_{ji}, \overline{Z}^{m}_{ji}, \overline{Z}^{u}_{ji}\right) =$$

$$= \left(\frac{1}{q}\sum_{k=1}^{q} Z^{l}_{jik}, \frac{1}{q}\sum_{k=1}^{q} Z^{m}_{jik}, \frac{1}{q}\sum_{k=1}^{q} Z^{u}_{jik}\right), \tag{9}$$

where Z^l_{jik}, Z^m_{jik}, Z^u_{jik} represent the lower, medium and upper values of each fuzzy values. Then a scalar measure of the dominance of the alternative i over other ones is defined as

$$d_i = \min_{\substack{l=1,n \\ l\neq i}} V\left(\tilde{S}_i \geq \tilde{S}_l\right), \left(i=\overline{1,m}\right). \tag{10}$$

The best alternative is with the $\max_{i=1,n} d_i = 1$.

We can see that the Fuzzy approach requires much more information obtained from the experts and is more complicated. The reasons for which the Fuzzy method may be more adequate are: uncertainty of an expert as to his preferences, lack of information, and existence of different opinions of experts. In this paper we used Pareto and Fuzzy methods.

6. RESULTS OF RANKING ALTERNATIVES OF UPDATING ADCS OF UBPS

The problem was solved by three experts E_1, E_2, E_3. We represent a detailed description of the work done by E_1, and final results of E_2 and E_3. The values of all utility functions Z_{ji} $(\overline{1,7}; i=\overline{1,3})$ are presented in Table 3 together with characteristic values Z^l_{ji}, Z^m_{ji}, Z^u_{ji} for fuzzy numbers Z_{ji} $(j=\overline{1.7}; i=\overline{1.3})$. So far we have no exact data on emission rates of SO_2 and NO_x from the thermal plants of UBPS at different conditions of their operation; therefore, values include percent evaluations of reducing the consumption of organic fuels due the updated ADCS and to the optimized performance of thermal–power plants using their economic characteristics. Also, the values of utility function Z_{3i} used in the evaluation assume a less than 5% reduction of the NO_x emission due the modern optimal control of UBPS. Regarding the emission rates of SO_2 and NO_x, the alternatives X_2 and X_3 are worse than the alternative X_1, because the AGFC of Baltic DC must control the some power plants with no respect to the NDCs. From the point view of independence of NDCs, the alternative X_3 is worse than X_1 and X_2, as it excludes the possibility of controlling the intersystem power flows. Experts E_2 and E_3 were less certain about the Z_{1i} and Z_{2i} values, because they expected large updating costs and longer pay-off periods.

Results of ranking the alternatives by experts is presented in Table 4. We obtain that X_2 is a distinct leader in our ranking results. After X_2 follows the alternative X_3, and after X_3 follows X_1. It should be noted that the measure of the dominance of the alternative X_3 over the other ones, d_3 = 0.98–0.99.

Table 3. **Utility function values Z_{ji} and corresponding numbers (Z^l_{ji}, Z^m_{ji}, Z^u_{ji}) of fuzzy values Z_{ji} $(j=\overline{1.7}; i=\overline{1.3})$ evaluated by expert E_1.**

Utility function values Z_{ji} Characteristic values of fuzzy numbers Z_{ji}	Importance weights w_j of utility functions Z_{ji}	Alternatives		
		X_1	X_2	X_3
Z_{1j}	0.14	1.0	0.7	0.8
(Z^1_{1i}, Z^m_{1i}, Z^u_{1i})		(0.9; 1.0; 1.0)	(0.6; 0.8; 0.9)	(0.7; 0.8; 0.9)
Z_{2I}	0.14	1.0	0.9	0.9
(Z^1_{2i}, Z^m_{2i}, Z^u_{2i})		(0.9; 1.0; 1.0)	(0.8; 0.9; 1.0)	(0.8; 0.9;.1.0)
Z_{3I}	0.14	0.9	0.8	0.8
(Z^1_{3i}, Z^m_{3i}, Z^u_{3i})		(0.7; 0.9; 1.0)	(0.6; 0.8; 1.0)	(0.6; 0,.8; 1.0)
Z_{4I}	0.22	0.3	0.8	0.8
(Z^1_{4i}, Z^m_{4i}, Z^u_{4i})		(0.1 0.3; 0.5)	(0.7; 0.8; 1.0)	(0.7; 0.8;.1.0)
Z_{5I}	0.08	0.1	0.8	0.8
(Z^1_{5i}, Z^m_{5i}, Z^u_{5i})		(0; 0.1; 0.2)	(0.7; 0.8; 1.0)	(0.7; 0.8; 1.0)
Z_{6I}	0.14	0.9	0.8	0.6
(Z^1_{6i}, Z^m_{6i}, Z^u_{6i})		(0.8; 0.9; 1.0)	(0.7; 0.8; 1.0)	(0.5; 0.6; 0.8)
Z_{7I}	0.14	0.5	0.8	0.8
(Z^1_{7i}, Z^m_{7i}, Z^u_{7i})		(0.1; 0.5; 0.7)	(0.7; 0.8; 1.0)	(0.7; 0.8; 1.0)

Table 4. **Results d_i of ranking alternatives by the Pareto and Fuzzy methods as presented by three experts**

Alternatives	Experts								
	E_1			E_2			E_3		
	Pareto	Fuzzy	Average	Pareto	Fuzzy	Average	Pareto	Fuzzy	Average
X_1	0.84	0.74	0.79	0.81	0.81	0.81	0.88	0.80	0.84
X_2	1.0	1.0	1.0	0.98	0.98	0.98	1.0	1.0	1.0
X_3	0.96	0.95	0.955	1.0	1.0	1.0	0.99	0.99	0.99

Therefore, the alternatives X_2 and X_3 are close each other.

7. CONCLUSIONS

1. A multiobjective problem to rank the alternatives of updating the ADCS of PS was found.

2. Ranking the alternatives of updating the ADCS of PS is performed by some experts with the help of decision support software facilitating the implementation of three different ranking methods: Paired Comparisons of Alternatives, Pareto and Fuzzy, using triangular fuzzy numbers. The last method yields the closest approximation for uncertainties of the expert's experience in evaluating the utility criteria or utility functions.

3. Ranking the three alternatives of updating the ADCS of Unified Baltic Power System was performed by three experts using Pareto and Fuzzy ranking methods. The ranking shows that both X_2 and X_3 alternatives have a nearly equal rank and are very close to unity. The alternative X_1 has a distinctly lower rank and is the worst.

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BALTIJOS JUNGTINĖS ENERGETIKOS SISTEMOS ADVS MODERNIZAVIMO VARIANTŲ DAUGIAKRITERINĖ ANALIZĖ

S a n t r a u k a

Lietuvos, Latvijos ir Estijos elektros energetikos sistemose esančios automatizuoto dispečerinio valdymo sistemos (ADVS) yra morališkai ir fiziškai susidėvėjusios, nepritaikytos dirbti rinkos sąlygomis, jomis sunku vykdyti duomenų įvertinimo ir analizės funkcijas, stebėti tinklą. Dėl to ADVS sistemos jau pradėtos pertvarkyti, įrengiant naujas SCADA (Supervisory Control and Data Acquisition) ir energijos valdymo sistemas. Šiame straipsnyje pateikiami trys tikėtiniausi Baltijos šalių ADVS sistemų pertvarkymo variantai. Variantai analizuojami pasitelkus daugiakriterinės analizės priemonę, sudarytą iš trijų matematinių metodų: porinių palyginimų, Pareto ir neryškių (miglotų) dydžių. Tai ekspertiniai metodai, įgalinantys atlikti analizę neturint visos informacijos. Pateikiamas išsamus šių metodų aprašymas ir ranžavimo rezultatai. Geriausia alternatyva randama pagal septynis kriterijus: ADVS modernizavimo kainą, atsipirkimo trukmę, SO_2 ir NO_x teršalų, išskiriamų į atmosferą, kiekį, AGDV ir UQAR galimybę, elektros energijos gamintojų tarpusavio konkurencijos galimybę, prisijungimo prie Vakarų Europos energetinių sistemų galimybę, ADVS savarankiškumo laipsnį.

Raktažodžiai: automatizuota dispečerinio valdymo sistema, nacionalinis dispečerinis centras, jungtinė energetikos sistema, valdymo rajonas

Антанас Немура, Дарюс Балакаускас

МНОГОКРИТЕРИАЛЬНЫЙ АНАЛИЗ ВАРИАНТОВ МОДЕРНИЗАЦИИ ОБЪЕДИНЕННОЙ ЭНЕРГОСИСТЕМЫ БАЛТИЙСКИХ ГОСУДАРСТВ

Р е з ю м е

Существующие системы автоматизированного диспетчерского управления (АСДУ) в энергосистемах Балтийских государств – Латвии, Литвы и Эстонии являются устаревшими и неэффективными. Они не приспособлены работать в условиях рынка. В связи с этим уже приступили к модернизации существующих АСДУ наряду с установкой новых современных систем контроля, управления, сбора и анализа данных (системы SCADA).

В настоящей статье представлены и проанализированы по наиболее важным критериям три вероятные варианта модернизации АСДУ объединенной энергосистемы трёх Балтийских стран. Анализ вариантов модернизации АСДУ приведён используя программное средство многокритериального анализа, предназначенное для помощи эксперту. Это программное средство позволяет применять три метода: метод попарных сравнений, Парето метод и метод нечётких множеств. Для анализа и сравнения вариантов модернизации АСДУ применены два последние метода и семь критериев: цена модернизации, срок окупаемости, количество SO_2 и NO_X, выбрасываемых в атмосферу, возможности автоматического регулирования перетоков мощности и узловых напряжений в системной сети, возможность присоединения к объединенной энергосистеме стран Западной Европы и степень самостоятельности национальных диспетчерских центров.

Ключевые слова: система автоматизированного диспетчерского управления, национальный диспетчерский центр, объединенная энергосистема, система сбора и анализа данных, район управления