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PROSPECTIVE DIRECTIONS FOR THE MODERNIZATION OF THE LOAD CONTROL SYSTEM OF THE CENTRAL ENERGY SYSTEM OF UKRAINE

Abstract. *Currently, the solution to the urgent issue of eliminating the shortage of maneuverable generating capacities existing in the United Energy System of Ukraine (UES) can be the introduction of automatically controlled complexes of powerful electric boilers (EB) into the existing automated dispatch control system (ADCS). The introduction of EB complexes to ADCS facilities will provide an opportunity to implement the processes of compacting the daily load schedule (SDEL), which will ensure the possibility of achieving better indicators of the energy, economic and environmental efficiency of the operation of the UES. For example, of in the energy region of the central energy system (CES), the issue of installing and using powerful electric boilers in the system of operating thermal power plants of cities is considered. The specifics of using powerful electric boilers in the summer season have been determined. The cited studies are of a recommendatory nature for the preparation and development of a new investment project.*
Keywords: Unified energy system, powerful electric boilers, automated dispatch control system (ADCS), schedule of daily electrical load (SDEL).

1. Introduction

As you know, in recent years there have been some changes in the structure of electricity consumption in the United Energy System of Ukraine (UES). The main consequence of such changes was a gradual decrease in energy consumption in industry and an increase in electricity consumption by the population. This led to an increase in the shortage of maneuverable generating capacities in the UES. It should be noted that the already existing shortage of maneuverable generating capacities in the UES was tried to be eliminated during the last few decades, but it was not possible to do so. The reason for this state of affairs was the use of only traditional methods and means of regime regulation, which primarily include the maneuverable power units of the Central Power Plant. The range of regulation of maneuverable power units of the TPP of the GC is quite limited and is only up to 15% of P_{nom}. [1]. Therefore, in order to form a reserve of maneuverable generating capacities of the power system, for example, in the amount of 1500 MW at the TPP power units of the Central Power Plant, it is necessary that the major part of their capacity, namely, in the of 10,0 GW, should be used in the basic part of the SDEL.

Table 1 shows the data of NEC "Ukrenergo" regarding the installed capacity of TPPs operating in the UESU, the number of installed power units, and the specific consumption of conventional fuel g/kWh.

Table 1. Data of thermal power plants (TPP) operating in the UESU

Name of EC	Operating TPPs	Installed capacity, MW	Number of power units	Specific consumption of conventional fuel, g/kWh
"Dniproenergo"	PRYDNIPROVSKA TPP	1765	4 × 150 + 3 × 285 + 310	406.8
	KRYVORIZKA TPP	2820	282 × 10	380.7
	ZAPORIZKA TPP	3600	4 × 300 + 3 × 285	365.0
"Donbasenergo"	STAROBESHIVSKA TPP	1825	12 × 175 + 200	425.0
	SLOVIAN TEAM	800	2 boilers + turb.	423.5
	UGLEGIRSKA TPP	3600	4 × 300 + 3 × 800	372.1
JSC "Zakhidenergo"	BURSHTYNSKA TPP	2300	8 × 195 + 3 × 185	412.2

Continuation of Table 1.

Name of EC	Operating TPPs	Installed capacity, MW	Number of power units	Specific consumption of conventional fuel, g/kWh
	DOBROTVIRSKA TPP	600	7 boilers + 3 turbos	419.4
JSC "Pivd-Zakhidna"	LADYZHYNSKA TPP	1800	6 × 300	377.5
OJSC "Centrenego"	TRIPILSKA TPP	1800	6 × 300	411.7
	ZMEIVSKA TPP	2200	6 × 175 + 3 × 275 + 300	380.7

The presence of most of the capacities of the TPP in the basic part of the SDEL of the NPP reduces the potential opportunities for using the generating capacities of the NPP and restrains their further development and commissioning [2].

Thus. it will be necessary to carry out appropriate modernization in the system of dispatching control of the load mode of the UES which will make it possible to achieve better indicators of energy economic and environmental efficiency of the power system [3, 4].

The purpose of the work is to modernize the management system of the Central EU regime.

2. Statement of the problem and purpose of research

It is assumed that due to the compaction of SDEL by automatically controlled means of ADCS with powerful electric boilers (EB), it will be possible to transfer part of the maneuverable power units of the TPP to the basic load mode. This will create the necessary conditions for the further development of NPP generating capacities in the UESU and the further gradual decommissioning of TPP power units. Replacing only 1000 MW of maneuverable capacities of TPP power units with nuclear power plants (NPP) will provide an opportunity to achieve an annual economic effect of the order of 1.532 billion dollars USA [5].

As of today the operational reserve of dispatching control of the load mode of the UES is formed from the maneuverable generating capacities of the power units of TPPs, as well as from the regulated capacities of HPPs and GAPPs. The conducted studies showed that in order to solve the issue of increasing the reserve of maneuverable capacities in the UES it is necessary to introduce powerful automatically controlled complexes of electric heat generators (CEG) to the control tools of the current ADCS as it is conventionally shown in Fig. 1 [5].

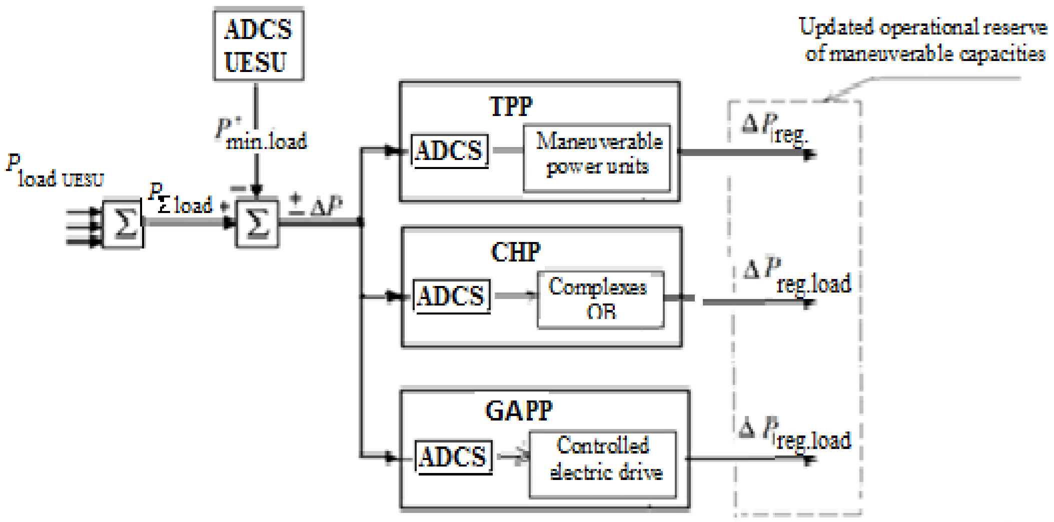


Fig. 1. Structural diagram of the updated operational reserve of maneuverable capacities of the unified energy system of Ukraine due to the use of an automatically controlled load of CEG complexes

3. Research results

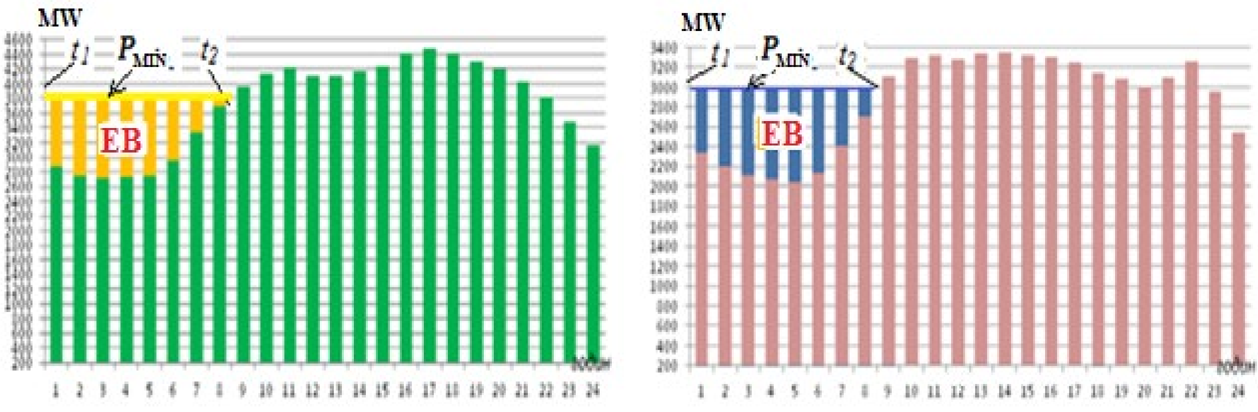
In order to solve the issue of SDEL compression in the Central PS (CPS) it will be necessary to install EB complexes at the thermal power plants (TPP) of a number of CPS cities, which will require consideration of the possibilities of their use in the summer season. In addition SDEL, compaction will also affect the operating mode of CPC generating stations. Let's consider these questions in more detail Table 2 shows data on the generating capacities of stations that participate in covering the current load of the CPS.

Table 2. Installed capacities of the generating stations involved in the Central PS

NPP		CHP		HPP		TPP	
Station	Install Power. MW	Station	Install Power. MW	Station	Install Power. MW	Station	Install Power. MW
Rivne NPP				Kyiv HPP	429.5	Trypil TPP	1800
1. VVER 440/213	420						
2. VVER 440/213	415	CHP -6	500	Kanivska HPP	472	Ladyzhin-skaya TPP	1800
3. VVER 1000/320	1000	CHP -5	700				
4. VVER 1000/320	1000	Darnytsia CHP	160	KyivGasPover Plant	235.5		
Khmelnytskyi NPP		Chernihiv thermal power plant	210				
1. VVER 1000/320	1000	Chernihiv thermal power plant	210	Dniester HPP	702		
2. VVER 1000/320	1000	Cherkasy CHP	200	Dnistrovsk HPP	296 MW +1684 MW (pump)		
		Bilotserkivska CHP	120				

In accordance with the data in Table 2 the maneuverable generating capacities of Trypilskaya TPP and Ladyzhinskaya TPP, as well as the hydroelectric power station (GAPP), participate in the coverage of the variable part of SDEL Central PS.

In order to implement the processes of compaction of DGEN CES in a given time period: (t1 – t2), starting, for example, from 11 pm to 8 am, it is assumed to be possible to apply an automatically controlled load of EC complexes, as conventionally shown in fig. 2. In this case after the compaction of SDEL the maneuverable generating capacities of Trypilskaya TPP and Ladyzhinskaya TPP will no longer be needed and will be transferred to the basic part of the daily load schedule.



a) b)

Fig. 2. Consolidation of the SDEL of the CPS by the automatically controlled load of EB complexes and the establishment of a new minimum load level (Pmin): a) in the heating period; b) in the summer season

It is assumed that the most promising place for the introduction of EC complexes will be the city of Kyiv, where there is an urgent need for densification of DGEN (table 4), as well as a real possibility of introducing these complexes into a powerful system of centralized heat supply (CTP) of TPP-5 and TPP-6. At the same time, automatic control of a load of EC complexes can be implemented directly at the dispatch centers of TPP-5 and TPP-6, as conventionally shown in the functional diagram of the TPP shown in Fig. 3.

In order to determine the electric load of EB complexes which can potentially be installed in the heating plants of cities and regional centers of the Central Power Plant we will present the data of the "Daily Information" of the NEC "Ukrenergo". As an example, let's use the graphs of changes in the daily load that took place in the regional centers of the CES on the control days of January and July 2018, given in the table.

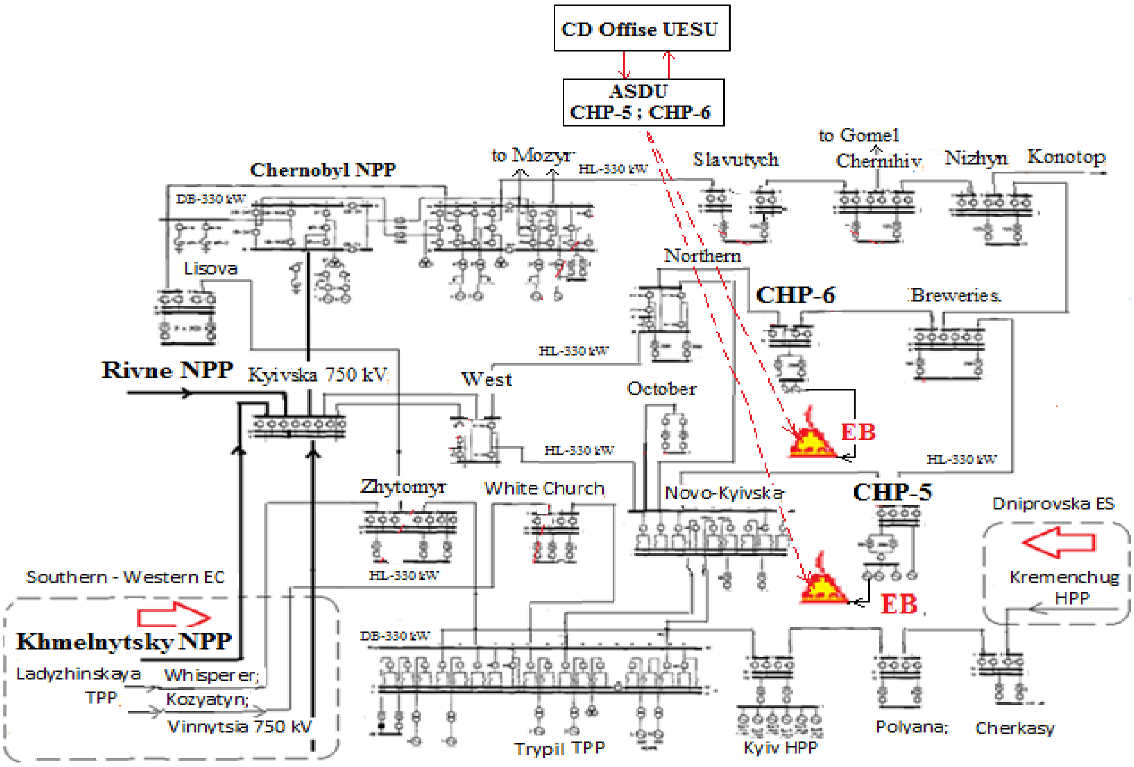


Fig. 3. Functional scheme of the Central EC with the indication of the places of potentially possible installation of EC complexes

Table 3. Average - statistical data of changes in the daily load in the Central PS on the control days of January and July 2018

Central PS - January 2018 (MW)							Central PS - July 2018 (MW)						
Zhyto-myr	Cherkasy	Kyivska	Kyiv	Cherni-hiv	Obl.	Central PS	Zhyto-myr	Cherkasy	Kyivska	Kyiv	Cherni-hiv	Obl.	Central PS
349	405	707	864	188	361	2874	264	334	577	864	151	153	2343
326	390	667	787	188	399	2757	248	310	533	787	145	174	2197
322	386	663	740	182	421	2714	229	297	530	740	148	165	2109
322	394	675	715	184	432	1722	238	295	520	715	143	153	2064
317	408	685	677	188	473	2748	242	302	526	677	142	148	2037
355	434	735	708	208	510	2950	245	324	533	708	159	167	2136
396	470	831	843	250	555	3345	270	347	599	843	173	173	2407
443	506	869	1010	275	596	3699	293	382	667	1010	204	168	2715
454	531	923	1201	294	554	3957	349	424	730	1201	223	184	3111
490	533	926	1297	301	590	4137	360	428	738	1297	235	229	3287
502	542	929	1332	300	605	4210	341	439	752	1332	230	227	3321
473	520	927	1320	288	592	4120	324	422	763	1320	224	232	3275
463	524	915	1352	282	578	4114	329	425	766	1352	219	249	3340
472	530	945	1359	291	570	4167	243	425	767	1359	216	236	3346
488	548	944	1351	297	618	4246	338	420	754	1351	211	250	3324
507	571	988	1334	328	672	4400	344	432	734	1334	212	249	3305
531	570	990	1312	336	724	4463	340	408	742	1312	212	231	3240
517	565	984	1258	327	761	4415	324	410	745	1258	211	198	3145
517	563	986	1215	316	699	4301	318	407	726	1215	209	201	3076
514	543	952	1152	303	727	4193	315	408	713	1152	204	226	3013
486	519	925	1151	291	652	4024	323	417	745	1151	217	236	3039
452	476	931	1185	263	515	3822	352	445	809	1185	228	240	3259
422	448	845	1055	239	474	3483	342	383	763	1055	205	220	2958
368	422	777	912	208	476	3163	284	334	626	912	178	196	2540

Thus, for the city of Zhytomyr (Table 3), there were changes in the daily load in the time interval: Δt = (t1 – t2) (Fig. 3), starting from 11 p.m. to 8 a.m., ranging from 454 MW to 317 MW. Therefore, for the city of Zhytomyr, it is necessary to raise the minimum load level and stabilize it at a new higher level: $P_{MIN.NAV.}$ = 454 MW. It will be possible to do this due to the use of an automatically controlled load of EC complexes the value of which is about 137 MW in ADCS facilities. Raising the minimum load level of SDEL in Zhytomyr will remove the need for further use of the maneuverable generating capacities of the Ladyzhinskaya TPP and will mean transferring them to the basic mode of the city's daily load schedule. The balance of capacities in the given time interval Δt of the Zhytomyr power station where the minimum load level was raised is written by the equation:

$$\frac{1}{T}\int_{t1}^{t2}\left[P_{Gener.(LadyzhinskaTPP)}(454MW)-P_{Land.(c.\text{Zhytomyr})}(454-317)MW+P_{EB}(137)MW\right]dt=0. \qquad (1)$$

Similar processes will take place in the city of Cherkasy where during the nighttime decline of the SDEL there was a load drop from 531 MW to 386 MW (Table 3). After the compaction of the SDEL there will be no further need for maneuverable generating capacities of the Trypil TPP, and its power units will be transferred to basic load mode. The requation of the power balance at the specified time interval: Δt = t1 – t2 SDEL in Cherkasy will look like this:

$$\frac{1}{T}\int_{t1}^{t2}\left[P_{Gener(\text{Trypil TPP})}(531MW)-P_{Land.(c.\text{Cherkasy})}(531-386)MW+P_{EB}(145)MW\right]dt=0. \qquad (2)$$

In the cities of "Kyiv region" during the nighttime decline of DGEN, the load drop was from 923 MW to 623 MW, that is, of the order of 300 MW (Table 3). If we assume that at the Trypil TPP during the year, the order of 3 power units was used, then the annual consumption of conventional fuel was:

$$\frac{1}{T}\int_{t1}^{t2}\left[P_{Gener.(\text{Ladyzhinskaya TPP})}(923MW)-P_{Land.(\text{Kyiv region.})}(923-623)MW+P_{EB}(300)MW\right]dt=0. \qquad (3)$$

Calculations were carried out to determine the electric load values of EB complexes in the city of Kyiv in the city of Chernihiv and the Chernihiv region and were performed in a similar way. Table 4 shows the results of the calculations.

Table 4. Electrical load values of EB complexes that can potentially be used in cities and regional centers of the Central PS

Name of the city or region	During the heating season (MW)	During the summer (MW)
Zhytomyr	137	120
Cherkasy	145	180
Kyiv region	300	220
m. Kyiv	**523**	**523**
Chernihiv	110	90
Chernihiv region	250	40
Total electric load of EC complexes	1465	1173

Thus regardless of the season, the greatest demand for maneuverable generating capacities took place in the city of Kyiv (Table 4).

Based on the results of the calculations was determined that after the compaction of SDEL will be possible to remove the generating capacities of Trypilskaya TPP and Ladyzhynskaya TPP from the Central PS replacing them with Riv NPP and Khm NPP capacities (Fig. 2).

Power units with a capacity of 300 MW have been installed at Trypilska TPP and Ladyzhynska TPP (Table 1). If we assume that at the Trypil TPP during the year, the order of 3 power units was used, then the annual consumption of conventional fuel was:

$$V_{fuel} = (8760 \times 300) \times 0.411 \times 3 \text{ (Power units)} = 1080.0 \times 10^3 \text{ t.c.f.}, \qquad (4)$$

where t.c.f. - a ton of conventional fuel.

And at Ladyzhynska TPP:

$$V_{fuel} = (8760 \times 300) \times 0.3775 \times 3 \text{ (Power units)} = 992.0 \times 10^3 \text{ t.c.f.} \quad (5)$$

The replacement of the generating capacities of the Trypil TPP and Ladyzhyn TPP used in the Tsentralnyi EU with the capacity of the RANP and KhaNPP will reduce the annual consumption of conditional fuel of the UES thermal stations by the amount of $V_{fuel} \approx 2072.0 \times 10^3$ tons of c.f.

<u>The component of thermal capacity of EC complexes.</u>

Thermal generation of EC electric boilers (Q_{EB}) in the centralized heat supply system (CHS) will take place during the given interval of the day:

$$\sum_1^e Q_{EB} = \frac{1}{T}\int_{t1}^{t2}\sum_1^e [Q_{EB1} + Q_{EB2} + \ldots + Q_{EBn}]dt, \quad (6)$$

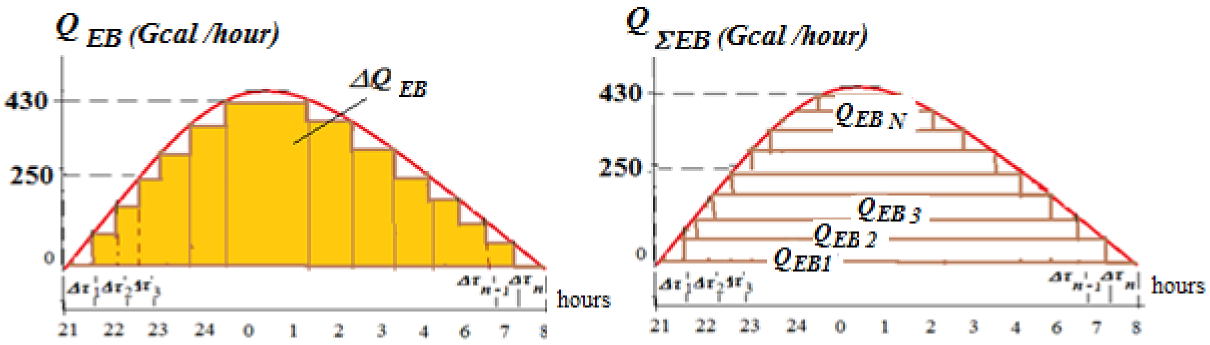
where Q_{EB} is the heat capacity of a separate electric boiler.

The general equation of the heat balance for the introduction of thermal capacities of Q_{EB} into the centralized heat supply system of cities will have the following form:

$$\frac{1}{T}\int_{t1}^{t2}\left[\begin{array}{l}\sum_1^k\sum_1^n\left[(Q_{CNS}^{Gener} - \Delta Q_{CNS}^{'}) + \Delta Q_{EB}^{'}\right] + \sum_1^m\sum_1^e (Q_{HBR}^{Gene} - \Delta Q_{HBR}^{''}) + \\ + \sum_1^m\sum_1^e (\Delta Q_{EB}^{'} + \Delta Q_{EB(\text{accumulation})}) = 0\end{array}\right]dt = 0, \quad (7)$$

where k – is the number of STCs; n - the number of CHPs in the SCT; m – the number of heating boiler rooms (HBR); e –is the number of electric boilers in the EB complex.

Let's consider the issue of the possibility of using the thermal capacities of EC complexes in the summer season. For example in fig. 4 (a) shows the estimated schedule of thermal generation of EC complexes in the system of the CHS of the city of Kyiv.



a) b)

Fig. 4. The thermal mode of generation of EB complexes using their electric load in the processes of SDEL compaction: a) thermal generation of electric boilers of EB complexes; b) distribution of thermal load of complexes between individual EB

The processes of generation of thermal power of EC complexes $Q_{(EB)}$ (Fig. 4a) will take place alternately as shown in Fig. 4(b). The discrete nature of the thermal power generation of each of the Q_{EB} electric boilers (Fig. 4b) is written as follows:

$$\begin{cases} Q_{(EB)1} = \Delta Q_1(T - 2\tau_1); \\ Q_{(EB)2} = \Delta Q_2\left[T - 2(\tau_1 + \tau_2)\right]; \\ Q_{(EB)3} = \Delta Q_3\left[T - 2(\tau_1 + \tau_2 + \tau_3)\right]; \\ \ldots \ldots\ldots \ldots\ldots \ldots\ldots \ldots \\ \Delta Q_{(EB)N} = \Delta Q_3\left[T - 2(\tau_1 + \tau_2 + \ldots + \tau_N)\right] \end{cases} \quad (8)$$

And the total technological power of thermal energy of the entire complex is represented by the equation:

$$\frac{1}{T}\int_{t1}^{t2} Q(\tau_{\Sigma EB})dt = \sum_{\tau 1}^{\tau_N}[Q_{EB1} + Q_{EB2} + Q_{EBN}] =$$
$$= \sum_{\tau 1}^{\tau_N}\left[\pm\frac{1}{\Delta\tau}\int_{\tau_1}^{\tau_2}(\Delta Q_1)d\tau \pm \frac{1}{\Delta\tau}\int_{\tau 2}^{\tau 3}(\Delta Q_2)d\tau \pm \frac{1}{\Delta\tau}\int_{\tau_{N-1}}^{\tau_N}(\Delta Q_N)d\tau.\right] \quad (9)$$

Each of the EB electric boilers will provide a certain amount of electric and thermal energy generation which will need to be more evenly distributed during the nighttime interval of SDEL for example as shown in Fig. 5.

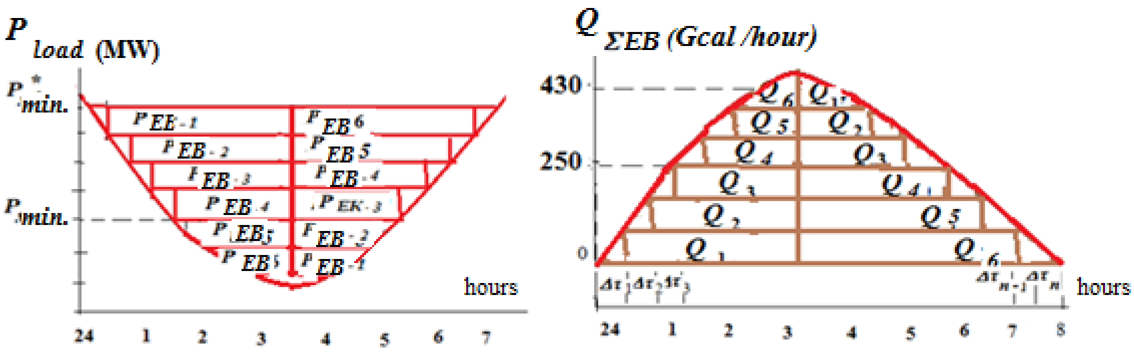


Fig. 5. Schedules of compression of the nighttime drop in the SDEL power system load by EB complexes: a) processes of ensuring the uniformity of the time of use of the EB electric boilers involved in the work; b) processes of corresponding changes in heat generation of EB electric boilers

In order to reduce the time of use of each of the EC complexes in the summer season, it is necessary to provide a certain resource of reserve capacity for these complexes, similar to what happens during the operation of thermal power plants [6], as well as modern management systems for generating capacities of wind turbines and thermal power plants [7].

Thus, if the active and reserve capacity resource of EC complexes will consist, for example, of 12 electric boilers, then in the summer season, when DGEN is compacted, it will be possible to use each of these electric boilers only for a certain (set) time, as conventionally shown in Fig. 6a. Note that to reduce the time of use of each of the EC electric boilers, the method of time permutations can also be applied (Fig. 6b) [8].

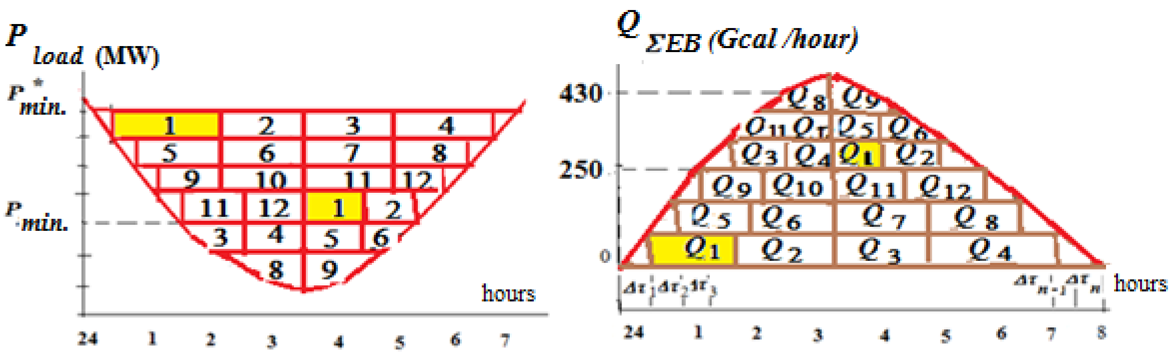


Fig. 6. Schedules for the compression of the nighttime drop in the SDEL load of the power system with the simultaneous use of the available and reserve load capacity resources of the EB complexes: a) processes of reducing the time of use of EB electric boilers involved in work; b) the duration of heat generation processes of individual EB electric boilers

Thus in the summer season. the following methods can be used to create and further use the required (set) amount of electrical capacity reserve of EB complexes:

- accumulation of thermal energy in the heating networks of the CPS in the summer [9, 10];

- thermal energy accumulations in individual EB heating boiler houses [11, 12];

- reduction of heat generation of EB complexes involved in work due to the simultaneous use of the available and reserved resource of load capacities of EB complexes.

4. Conclusions

The conducted studies showed that due to the compaction of SDEL in the Central PS. it will be possible to:

- dispatchers of TPP-5 and TPP-6. together with dispatchers of HPP (HAPP) perform almost all processes of adjusting the load mode in TPP during the day;

- to apply an automatically controlled load of EB complexes in ASDU TPP-5 and TPP-6 facilities and to eliminate excess generating capacities of WPPs and SPPs in the energy system;

- to increase the use of generating capacities of the RANP and Kha NPP due to the withdrawal from the energy supply of the Trypil TPP and the Ladyzhyn TPP;

- to reduce the existing shortage of maneuverable generating capacities in the UES.

The methods discussed in the article regarding the use of powerful electric boilers in the summer season may also be promising for the further practical application of EB complexes.

The methodical studies carried out are aimed at their use in the development of a new investment project aimed at modernizing the system of managing the load regime of the Central PS.

References

1. Venikov, V.A. (1973). Electrical calculations. programming and optimization of regimes: "Vysshaya shkola". 316 p.
2. Lenchevsky, Ye.A., & Godun, O.V. (2021). The review of the possibility to increase the integrated power system of Ukraine' balance reliability by implementing electric heat generators. *The Problems of General Energy*, 2(65), 36–43 [in Ukrainian]. https://doi.org/10.15407/pge2021.02.036
3. Lenchevsky, Ye.A. (2019). Features of the use of electric heat generators in the processes of compaction of diurnal graphs of the electrical load of a power system. *The Problems of General Energy*, 1(56), 53–58 [in Ukrainian]. https://doi.org/10.15407/pge2019.01.053
4. Lenchevsky, E.A., Godun, A.V., & Novikov, P.V. (2021). Justification of the possibility the issue of ensuring frequency stability in the unified energy system of Ukraine at the level of ENTSO-E power interconnection. *Automation of technological and business processes*, 13(3), 22–30. https://doi.org/10.15673/atbp.v13i3.2147
5. Lenchevsky, E.A. & Teslenko, O.I. (2021). Promising possibilities of increasing the overall potential of maneuverable capacities of the unified energy system of Ukraine. *Scholarly notes of Vernadsky National Technical University Series: Technical sciences*, 32(71), 3, 194–202. URL: www.tech.vernjournals.in.ua
6. Chernousenko, O.Yu. (2014). State of energetics in Ukraine and results of modernization of power-generating units at TPP. *The Problems of General Energy*, 4(39), 20–28 [in Ukrainian].
7. Petryk, I. (2019). Ten cheapest power plants. Energy publications.
8. Katkov, F.A. (1967). Telecontrol. K.: Technique, 370 p.
9. Podobed, V.S. (2011). Accumulation of thermal energy in water heating networks. *Energy strategy*, 5(23), 22–26.
10. Derii, V.O. (2014). Potential of thermal energy accumulation in district heating systems networks. *The Problems of General Energy*, 4(39), 29–33.
11. Bilodid, V.D., & Derii, V.O. (2015). Heating system accumulative capability. *The Problems of General Energy*, 3(42), 31–35. https://doi.org/10.15407/pge2015.03.031
12. Parasochka, S.O. & Khryashchevskiy, V.M. (2008). Regarding the efficiency of electric storage heating when using hybrid electric-gas boilers. *Housing-communal economy of Ukraine*, 6(19), 34–38.
13. Parasochka, S.O. & Khryashchevskiy, V.M. (2009). To the question of electric storage heating and hot water supply. *Housing-communal economy of Ukraine*, 8(21), 34–38.

ПЕРСПЕКТИВНІ НАПРЯМКИ ПРОВЕДЕННЯ МОДЕРНІЗАЦІЇ СИСТЕМИ УПРАВЛІННЯ РЕЖИМОМ НАВАНТАЖЕННЯ ЦЕНТРАЛЬНОЇ ЕНЕРГЕТИЧНОЇ СИСТЕМИ УКРАЇНИ

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Анотація. *На сьогодні вирішенням актуального питання з усунення існуючого в Об`єднаній енергосистемі (ОЕС) України дефіциту маневрених генеруючих потужностей може стати введення до засобів діючої автоматизованої системи диспетчерського управління (АСДУ) автоматично керованих комплексами потужних електрокотлів (ЕК). Введення комплексів ЕК до засобів АСДУ надасть можливість реалізувати процеси ущільнення добового графіка електричного навантаження (ДГЕН), що забезпечить можливість досягнення кращих показників енергетичної, економічної та екологічної ефективності роботи ОЕС України. На прикладі енергорегіону, що відноситься до Центральної енергетичної системи України (ЦЕС), розглянуто питання щодо можливості встановлення та використання потужних електрокотлів у системі діючих теплоелектроцентралей міст. Визначено особливості використання потужних електрокотлів у літній період року. Приведені дослідження мають рекомендаційний характер для підготовки та розробки нового інвестиційного проєкту.*

Ключові слова: Об'єднана енергосистема. потужні електрокотли (ЕК), автоматизована система диспетчерського управління (АСДУ), графік добового електричного навантаження (ДГЕН).

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