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WAYS TO SAVE FUEL AND ENERGY RESOURCES IN DAILY GRAFT

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Summary. *Through experience it has been set the influence of various types of heat sources (gas stove for 4 burners, induction cooktop and electric kettle), volumes of water, the diameter of gas stove burners (55 mm, 75 mm, 100 mm), the diameter of tanks for water heating till boiling on energy-saving for cooking in household conditions. It has been proved that: a) the best device for cooking in house conditions is the induction cooker; b) in case of water heating till boiling, on gas stove, there has been observed an increasing of efficiency factor. This happens in the direction of increasing the ratio of the pot diameter to the burner diameter; c) for all heat energy sources is typical that with increasing the volumes of water is increasing the efficiency factor of its heating till boiling process.*

Key words: *energy saving, efficiency factor, temperature, water, gas stove, induction cooktop, electric kettle.*

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Problem statement. The situation in the energy sector of Ukraine continues to deteriorate. There is take place aging of power energy producing without ensuring of their modernization and replacement. The cost of transportation heat and electric energy to consumers is rapidly rising.

This leads to a significant increasing in tariffs for energy companies' services to middle European signatures. The acceleration of this growth is becoming more obvious for population – the main consumer of electricity and heat.

Taking into account the depletability of fossil fuel and energy resources (FER) and steady uncontrolled growth of population on the Earth, the question of saving FER has become a top-priority. Though resolution of this issue is unable in global dimension to solve energy hunger. Parallel to this is necessary to develop and implement renewable energy sources.

Analysis of recent research and publications has shown [1 – 7] that the issue of FER savings in companies related to the production, transmission and consumption of electricity and heat given enough attention.

To reduce losses there has been developed a lot of various measures, technologies and devices [8 – 9]. In the lighting – this is LED light sources, electronic control gears, built-operated timers or interfaces DALI DSI, 1-10 V with photosensor of light levels [10, 11].

In buildings – a variety of ways insulation of buildings [1], the usage of modern heating appliances and systems management [2]. For accounting energy resources there has been developed modern, multi-meters of heat and electricity. For the preparation of food – energy-saving pressure cooker, multicookings, induction cooker etc. But there is no scientifically based recommendations for the usage of energy saving electric kettles, gas and induction cookers in everyday life. Thrive exceptionally advertising message. This points on the actuality of carrying out of works related to determining energy-efficient ways of consumption energy resources at home [12 – 17]. Despite their pettiness, they can provide substantial savings of energy resources in country. That is why **the goal of this work** is the determination of fuel and energy resources saving ways in daily graft.

Set of a problem. Experience has shown the influence of various types of heat sources

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(gas stove for 4 burners, induction cooktop and electric kettle), volumes of water, the diameter of gas stove burners (55 mm, 75 mm, 100 mm), the diameter of tanks for water heating till boiling on energy-saving for cooking in household conditions.

Research results. For the experiments, of saving electric energy in everyday life were chosen the following devices: 1 – gas stove for 4 burners with diameter of burners 55 mm, 75 mm, 100 mm, 2 – induction cooktop Sensor model SCP 3201GY with the power of 0 – 1800 W; 3 – electric kettle Saturn with 1700 ml capacity and power of 2200 W; Tableware 1 – dimensional capacity of 1000 ml; 2 – pans of Rondell firm (see. table. 1), enameled cup by capacity of 1000 ml, by diameter 112 mm, by height 117 mm. Measuring devices: Energy meter Lemanso LM669 at maximum power 3680 W, gas meter G4 GALLUS 2000 G4 and mercury thermometer 0 – 200°C TU 25-2021.010-89 TTM.

Table № 1

Dimensions of containers

Diameter, mm	Height, mm	Volume, ml
137	70	750
195	115	3000
235	120	4000
235	115	4000

Experimentation sequence:

1. Measuring the temperature of water after filling of containers from the water tap;
2. Heat the water to a boil in lidded containers, monitoring: environmental temperature indoors, boiling temperature, time, during which water is heated to boil and consumed electricity (or gas volume). Repeat this experiments only after cooling to room temperature heaters parts and containers (pots) for different:

– the diameter of pots (see table № 1);
– the diameter of the burners on a gas stove;
– quantities of water in a pot: 250 – 3000 ml.

The water temperature of bib cock was equal to 18,25°C, environmental temperature in the kitchen was equal to 24°C.

The transition from quantity of consumed gas to kW·h was based on converting energy values diagram [12] by multiplying the quantity of gas consumed on a coefficient 9,346 m^3. Determination of the estimated (ideal) energy consumption for heating a certain amount of water was carried out by formula:

$$Q = c \cdot m \cdot (t_2 - t_1), \qquad (1)$$

where c – water specific heat, c = 4200 J / (kg·°C); m – water mass, kg; t_2 – measured value of steam point (98°C); t_1 – cold-water temperature from big cock (18,25°C).

The value of the efficiency coefficient water heating process from the temperature t_1 to t_2 defined as the ratio of energy costs estimated results by the formula (1) to experimental data. The results of measurements and calculations are shown in table № 2.

Table № 2

The results of experimental investigations of fractional heating water to a boil on a gas stove with different diameter of burners

Heating water on a gas stove in a pan by Rondell firm Ø 195 mm, h = 115 mm, on burner Ø 55 mm								
V, *l*	0,25	0,5	1,0	1,5	2,0	2,5	3,0	Øp / Øb
W, W·h,	75	125	211	287	357	420	485	3,54
t, sec	286	476	792	1068	1320	1557	1777	
EF, %	30	38	48	51	55	57,5	59,5	

Continuation the table № 2

Heating water on a gas stove in a pan by Rondell firm Ø 195 mm, h = 115 mm, on burner Ø 75 mm							
V, *l*	0,25	0,5	1,0	1,5	2,0	2,5	3,0	Øp / Øb
W, W·h,	85	142	240	326	404	478	549	2,60
t, sec	300	450	770	1065	1376	1557	1760	
EF, %	24	32	40	50	48	50,5	53	
Heating water on a gas stove in a pan by Rondell firm Ø 195 mm, h = 115 mm, on burner Ø 100 mm till boiling								
V, *l*	0,25	0,5	1,0	1,5	2,0	2,5	3,0	Øp / Øb
W, W·h,	110	175	277	362	438	508	574	1,95
t, sec	165	261	411	535	646	747	843	
EF, %	21	28	35	39	42	45	46	
Heating water on a gas stove in a pan by Rondell firm Ø 235 mm, h = 120 mm, on burner Ø 55 mm till boiling								
V, *l*	0,25	0,5	1,0	1,5	2,0	2,5	3,0	Øp / Ø b
W, W·h,	77	123	195	255	309	358	405	4,27
t, sec	263	452	778	1068	1338	1594	1838	
EF, %	26	37	48	54	59	62	65	
Heating water on a gas stove in a pan by Rondell firm Ø 235 mm, h = 120 mm, on burner Ø 75 mm till boiling								
V, *l*	0,25	0,5	1,0	1,5	2,0	2,5	3,0	Øp / Øb
W, W·h,	99	152	233	299	357	410	459	3,13
t, sec	192	322	540	731	907	1071	1228	
EF, %	18	39	40	46	51	54	57	
Heating water on a gas stove in a pan by Rondell firm Ø 235 mm, h = 120 mm, on burner Ø 100 mm till boiling								
V, *l*	0,25	0,5	1,0	1,5	2,0	2,5	3,0	Øp / Øb
W, W·h,	112	174	270	348	418	481	540	2,35
t, sec	153	248	403	535	655	766	870	
EF, %	17	25	34	39	43	45	48	

***Remark**. At the table 2 there has been marked: V – portions of water, *l*. W – the amount of electricity consumed to heat portions of water to a boil, W·h. t – the time taken to bring portions of water to a boil, sec. Efficiency Factor – EF %, Øp, Øb – diameter the bottom of pan and burner on a gas stove respectively.

Table № 3

The results of experimental investigations of fractional heating water to a boil on induction cooktop

Heating the water on an induction cooker (1800 W) to a boil in a pan (195 mm)							
V, *l*	0,25	0,5	1,0	1,5	2,0	2,5	3,0	Øp / Øb
W, W·h,	37	69	132	191	249	304	357	195/195 = 1,00
t, sec	74	138	263	383	498	609	714	
EF, %	61	65	69	72	73	75	76	

Table № 4

The results of experimental investigations of fractional heating water to a boil in electric kettle with volumetric capability 1,7 *l*

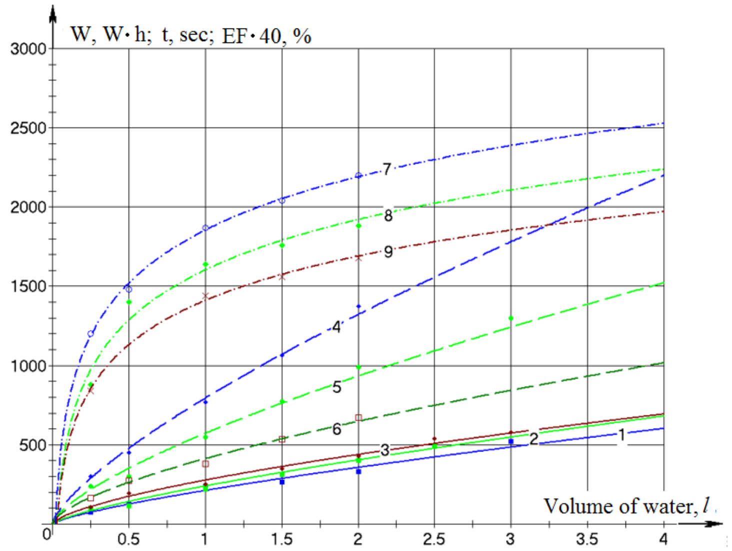
Heating the water in electric kettle (2200 W) to a boil							
V, *l*	0,25	0,5	1,0	1,5	2,0	2,5	3,0	Øp /Øb
W, W·h,	40	74	141	209	276	343	411	145/145 = 1,00
t, sec	66	121	231	341	451	562	672	
EF, %	45	58	63	65	66	7	67,5	

Table № 5

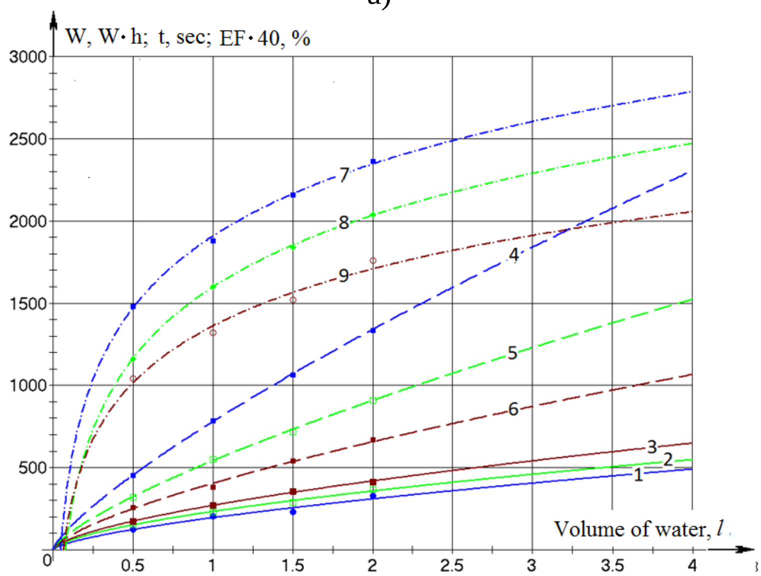
The results of experimental investigations of heating water to a boil on a gas stove in 1000 ml enamel pan with diameter 112 mm and height 117 mm

Parameters	Diameter of the burner 55 mm		Diameter of the burner 75 mm		Øp /Øb
V, *l*	0,5	1,0	0,5	1,0	112/55 = 2,04
W, W·h,	126,2	219,6	247,7	364,5	
t, sec	485	850	570	870	112/75 = 1,49
EF, %	0,31	0,41	0,18	0,25	

According to data in the table 2 – 4 there have been built corresponding graphic dependences (see figure 1 and 2). Moreover, for the convenience of estimates, all graphic dependences have been approximated by relevant analytical functions that were listed in the table № 6 and № 7.



a)



b)

Figure. 1. Dependence the amount of electricity W (W h) required to bring the water in the pot by diameter: a) 195 mm; b) 235 mm to boiling on a gas stove, heating duration t (sec) and efficiency factor (%) from volume portions of water V (l). Electricity consumed on the burner by diameter 1 – 55 mm; 2 – 75 mm; 3 – 100 mm. The duration of heating water on the burner by diameter 4 – 55 mm; 5 – 75 mm; 6 – 100 mm. The efficiency of the burner diameter 7 – 55 mm; 8 – 75 mm; 9 – 100 mm.

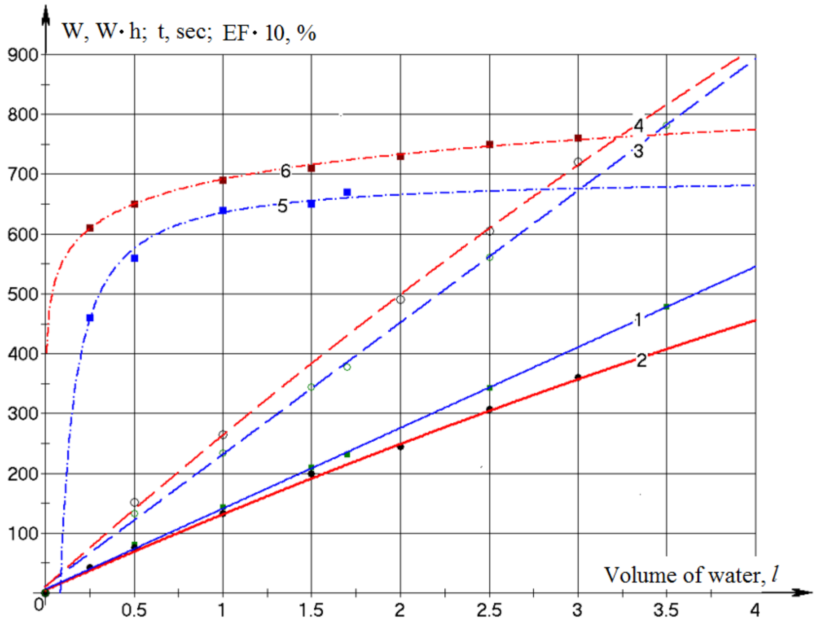


Figure 2. Dependence the amount of electricity W (W·h) required to bring the water in the electric kettle and in the pot by diameter 235 mm on induction stove to boiling, heating duration t (sec) and efficiency factor (%) by volume portions of water V (*l*). Electricity consumed by 1 – electric kettle; 2 – induction stove. The duration of heating water 3 – in the electric kettle; 4 – on induction stove. Efficiency water heating process 5 – in electric kettle; 6 – in induction stove

Table № 6

Analytical expressions of graphical dependences Figure 1

Figure 1,a	Figure 1,b
1 – $W_{195/55} = 211{,}5252 \cdot V^{0{,}755}$,*	1 – $W_{235/55} = 194{,}6896^{0{,}666}$,
2 – $W_{195/75} = 240{,}058 \cdot V^{0{,}752}$,	2 – $W_{235/75} = 232{,}8177 \cdot V^{0{,}618}$,
3 – $W_{195/100} = 276{,}8989 \cdot V^{0.663}$,	3 – $W_{235/100} = 269{,}744 \cdot V^{0{,}632}$
4 – $t_{195/55} = 792{,}93 \cdot V^{0{,}736}$,	4 – $t_{235/55} = 777{,}592 \cdot V^{0{,}783}$,
5 – $t_{195/75} = 571{,}198 \cdot V^{0{,}707}$,	5 – $t_{235/75} = 540{,}2255 \cdot V^{0{,}747}$,
6 – $t_{195/100} = 410{,}984 \cdot V^{0{,}653}$,	6 – $t_{235/100} = 403{,}054 \cdot V^{0{,}7}$,
7 – $\eta_{195/55} = 485{,}49 \cdot \ln(V) + 1853$,	7 – $\eta_{235/55} = 633{,}65 \cdot \ln(V) + 1905{,}8$,
8 – $\eta_{195/75} = 458{,}68 \cdot \ln(V) + 1602$,	8 – $\eta_{235/75} = 629{,}91 \cdot \ln(V) + 1596{,}15$,
9 – $\eta_{195/100} = 404{,}374 \cdot \ln(V) + 1409$.	9 – $\eta_{235/55} = 501{,}442 \cdot \ln(V) + 1359{,}17$.

* indexes near W, t, and η: numerator – the diameter of the pot, denominator – the diameter of the burner on a gas stove

Table № 7

Analytical expressions of graphical dependences Figure 2

1 – $W_{EK} = 138{,}87 \cdot V + 6{,}28$,**	4 – $t_{IS} = -9{,}367 \cdot V^2 + 263{,}2 + 9{,}25$,
2 – $W_{IS} = -4{,}68 \cdot V^2 + 131{,}59 \cdot V + 4{,}63$,	5 – $\eta_{EK} = -60{,}34 / V + 695{,}62$,
3 – $t_{EK} = 220{,}42 \cdot V + 10{,}5$.	6 – $\eta_{IS} = 59{,}9 \cdot \ln(V) + 691{,}5$.

** indexes near W, t, and η : EK – electric kettle, IS – induction stove

Analysis of obtained dependences showed, that in all cases with increasing volumes of water is increasing not only the duration of the heating process until it is boiling, but also the amount of energy consumption and efficiency factor. At the heating on a gas stove the amount of energy consumption and duration of the heating, occurs on the one and the same law – power-law. At the heating water in the electric kettle and in the induction cooker the amount of electricity consumed and the duration of heating increases by the linear law, and efficiency factor – by hyperbolic.

Induction Cooker consumes the least energy under bringing water to a boil (357 W·h for 3 liters, against 411 W·h for electric kettle). Accordingly, for induction cooker is characteristically the highest efficiency factors which are rapidly increasing, reaching close to the maximum values in the volume of water 1 liter ($\eta_{IS} = 69{,}1\,\%$ against $\eta_{EK} = 63{,}5\,\%$).

The duration of heating on induction cooker slightly larger than on the electric kettle ($t_{IS} = 714$ s against $t_{EK} = 672$ s) only because the power of induction cooker is less than the power of the kettle in 2200 W / 1800 W = 1,22 times.

Conclusions

1. Best source of heat for cooking in house conditions is the induction cooker, in which the heating efficiency factor for 3 liters of water reaches 76%, 67,5% for the electric kettle and 59,5% for gas stove.

2. The use of induction cooker makes it possible to save time on cooking. So, to bring to a boil 3 liters of water on an induction cooker you need 714 s, and on the gas stove – 1777 s.

3. Increasing of efficiency factor at heating water to boiling on a gas stove is observed in the direction of rising ratio Øk / Øp. In the case of heat 1 liter of water: at Øk / Øp = 1,49 – the efficiency factor = 25%; at Øk / Øp = 2,04 – efficiency factor = 41%; at Øk / Øp = 2,6 – efficiency factor = 53%; at 3,13 – 57%; at 3,54 – 59%; at 4,27 – 65% (see tab).

4. For all heat sources is typical that with increasing volumes of water, increases the efficiency factor of it heating to boiling process. This indicates that, a single heating large volumes of water are more energy saving than the same amount of multiple small portions. So, for a single heating 3 liters of water on a gas stove you need 485 W·h while heating the same amount of water but portioned, for 1 liter you need at 211·3 – 485 = 148 W·h watts less energy (see table № 2).

5. Knowing the amount of consumed EE for bringing water to a boil on different sources of heat (gas stove, induction cooker, electric kettle, etc.), we can clearly identify which device is most advantageous to use for cooking at home, depending from the current energy tariffs.

6. For energy saving cooking of different vegetables and boiled potatoes we should use a minimum of water. The water can be heated in the electric kettle and poured boiling water on vegetables. Thus, they cooked faster and in them will remain larger number of nutrients.

7. When cooking dishes need to be closed by lids. So it will cook faster and power consumption will be lower.

8.When water (soup) boiled, the power of energy material (gas eye on a gas stove or electric cooker temperature) should be reduced. Above 100 ℃, it still does not heat up. To maintain the boiling temperature is enough to fewer quantity of energy material (according to our observations approximately in 2,5 – 3,0 times). This makes it possible to save money on cooking through rational use of energy.

9. It is necessary just follow our simple tips, to develop a habit to do so, and not otherwise. According to psychologists, it takes no more than three weeks [18].

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ШЛЯХИ ЕКОНОМІЇ ПАЛИВНО-ЕНЕРГЕТИЧНИХ РЕСУРСІВ У ПОБУТІ

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***Резюме**. Дослідним шляхом встановлено вплив різних типів джерел теплової енергії (газової плити на 4 конфорки, індукційної плити та електрочайника), об’ємів води, діаметра конфорок газової плити (55 мм, 75 мм, 100 мм), діаметра ємностей для нагрівання води до закипання на енергоощадність приготування їжі в побутових умовах. Доведено, що: а) найкращим приладом для приготування їжі в домашніх умовах є індукційна плита; б) зростання коефіцієнта корисної дії при нагріванні води до закипання на газовій плиті спостерігається в напрямку збільшення співвідношення діаметра каструлі до діаметра конфорки газової плити; в) для всіх джерел теплової енергії характерним є те, що при зростанні об’ємів води зростає й коефіцієнт корисної дії процесу її нагрівання до закипання.*

***Ключові слова**: енергоощадність, коефіцієнт корисної дії, температура, вода, газова плита, індукційна плита, електричний чайник, температура.*

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