The influence of environmental tax rates on the Levelized cost of heat on the example of organic and biofuels boilers in Ukraine

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Abstract. In December 2019, the European Commission officially presented The European Green Deal, a new EU economic development program aimed at achieving climate neutrality on the European continent by 2050. Many previous global, European, and national programs also aim to reduce emissions of pollutants into the atmosphere. In this context, one of the ways to reduce emissions is the development of alternative energy sources (in particular the wider use of biofuel boilers) and increasing environmental tax rates. When choosing the optimal heating boilers, the practice of using the levelized cost of heating (LCOH) indicator is common. Environmental pollution tax (as a component of LCOH) is calculated for the three most common types of boilers (for Ukrainian boiler houses) with a capacity of 4.65 to 58 MW, burning natural gas, coal, and fuel oil, as well as low-power boilers burning organic and biofuels, for existing environmental tax rates, for projected increasing in 4 times (according to the bill) and subject to the introduction of minimum and maximum rates in EU countries. It is established that at the current environmental tax rates in Ukraine there are almost no economic incentives for the introduction of technologies to reduce the concentration of pollutants in emissions, but increasing environmental tax rates may change this situation. This, in turn, once again suggests that changing environmental tax rates can be an effective tool for achieving sustainable development goals.

1 Introduction

At the present stage of development, humanity uses so many resources that for the future in the near future we will lack the resources of our planet. Therefore, the global concept for solving this problem has become "sustainable development" - a development that meets the needs of the modern generation without harming future generations.

In a situation of stability, two competing pillars of sustainable development: the economic and the environmental one, are in the lead – as long as the basic needs of most people are satisfied [1].

Ukraine has made a number of commitments to protect the environment and reduce pollutant emissions [2, 3, 4]. The EU has adopted Directive 2015/2193 of the European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants [5]. As this Directive is a supplement to Directive 2010/75 / EC (for installations over 50 MW), Ukrainian medium-capacity installations will have to prepare to comply with its standards.

Among budgetary and fiscal instruments for stimulating and ensuring sustainable development, environmental taxes occupy a prominent place.

In scientific publications and legislation of different countries, you can find different definitions of "environmental taxes". In particular, the legislation of Ukraine contains two such definitions that to some extent complement each other:

1) Environmental tax - a nationwide mandatory payment, which is based on the actual amount of emissions into the atmosphere, discharges of pollutants into water bodies, waste disposal, the actual amount of radioactive waste temporarily stored by their producers, the actual amount of generated radioactive waste and the actual the amount of radioactive waste accumulated before April 1, 2009 [6].

2) Environmental tax - a tax with a specific object of taxation, which clearly has a negative impact on the environment, or is aimed at taxing certain activities, goods or services so that the cost of environmental protection can be included in their price and/or guide producers and consumers for activities that are best for the environment [7].

Many countries around the world have long used this powerful toolkit, many are just beginning, but common to most countries is that legislation in this area is constantly improving, including changes in environmental tax rates.

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Ukraine is no exception. As of December 2020, there are 3 different bills in the Parliament of Ukraine, about increasing the rates of environmental tax in Ukraine.

Given that one of the industries that are significantly affected by environmental tax rates is heat, it is advisable to conduct a study on the effects of changes in environmental tax rates on economic and environmental pillars of sustainable development.

2 Literature review

This article is a continuation of previous research by the authors [8, 9]. A lot of work has been devoted to the study of the impact of environmental taxes on sustainable development goals. Consider the main ones for 2018-2020

The study [10] employs the GTAP-E-Power model with additional improvements to include non-CO 2 emissions to examine the impacts of such a policy on the Vietnamese economy. Authors show, that higher tax on coal would foster the extension of renewable energy sectors faster than the impacts resulted from increasing tax on petroleum products. The increased demands by the private sector for electricity generated from renewable sources signal the potential for sustainable development of the renewable electricity generation sectors in Vietnam.

In paper [11] authors consider from an environmental policy-maker perspective, how carbon reduction policies impact the economic competitiveness of the manufacturing sector and note that the obtained results offer support to both environmental policy-makers and corporate production and sustainability managers to determine whether it is technically feasible and profitable to replace traditional scheduling strategies with environmentally friendly scheduling strategies.

Article [12] study how new sustainable business models in the energy sector work, and investigate their risk profile, especially concerning the risk of regulatory changes.

Paper [13] investigates the determinants of environmental tax revenue.

Findings [14] clearly indicate that (a) the proportion of tourism energy consumption to national energy consumption in China will increase over time, (b) the impacts of a carbon tax on China's tourism fossil energy consumption, electricity consumption, and energy intensity will become increasingly weak, (c) the impacts of a carbon tax on electricity use are greater than the impacts on fossil fuel consumption, and (d) the impacts of different carbon taxes on the levels of energy consumption and energy intensity will vary to a significant degree between the different tourism sectors.

The study [15] introduced an original interdisciplinary assessment model of performance-based contracting for SO_2 emission control in Chinese coal power plants that involves key environmental policies including command-and-control regulations, market-based approaches, and administrative measures, as well as technology, market, and capital variables (Fig. 1).

Paper [16] describes a new carbon price mechanism with full emission coverage which developed within the framework of a global computable general equilibrium model (GTAP-E-PowerS) to enhance the capacity and accuracy for climate change and energy policy assessment. The results indicate that South Africa is likely to move to low carbon and sustainable economy with such a policy.

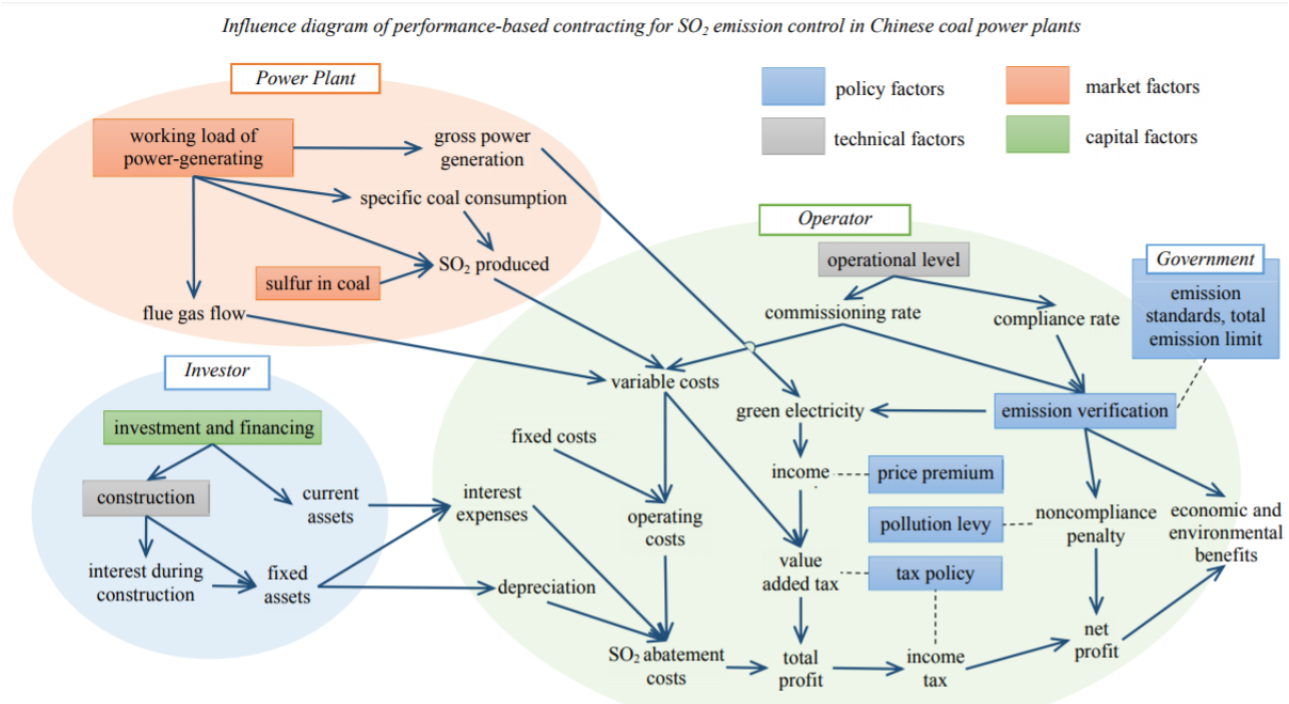

Fig. 1. Stakeholders, uncertain factors, and interactions in performance-based contracting for SO2 emission control in Chinese coal power plants. Arrows indicate the dependence; dashed lines indicate the environmental policy boundaries [15].

Article [17] shows, that the required carbon tax begins from $ 5.29/ton in 2020 and grows on average by 3.5% reaching up to $ 35.83 per ton carbon towards the year 2075.

In paper [18] is writing, that towards the reduction of greenhouse gas emissions, a carbon tax has been already introduced in 40 countries, but owing to different carbon prices among countries, there are potential risks of carbon leakage, where manufacturers transfer production operations to countries with lower taxes to pursue lower costs.

The paper [19] deals with the greening of tax systems in the European Union (EU) and reviews the achievements of the Baltic States in relation to greening their tax systems and implementing the sustainable energy development goals set by the EU's energy policies.

The Levelized cost of energy (LCOE) and its analog for heating - Levelized cost of heating (LCOH) are the widespread indicators, which is often used for cost comparisons for energy and heating generation [20-23 and other].

Paper [20] shows, that the application of the "traditional" LCOE formula has some problems, therefore authors present a modification to the traditional LCOE formula, which considers energy price rise and thus allows more accurate LCOE calculations.

The study [22] presents a new approach and methodology, which developed which uses the United Kingdom "audited" data, published in company accounts, that has been obtained from Companies House, to determine more accurate LCOE estimates.

The paper [23] provides the techno-economic comparative analysis of eight Biomass Integrated Gasification Combined Cycle (BIGCC) system designs that include the technology options of the biomass gasification, the power generation, and the CO_2 emission control. Results show that the LCOE of these systems is ranged from 0.131 $/kWh to 0.259 $/kWh.

3 Methods

The initial data for calculating emission taxes are the annual consumption of a particular type of fuel by the boiler plant (determined by the thermal capacity and efficiency of the boiler plant, its operating time, and installed capacity utilization factor), fuel calorific value, pollutant emission factors and eco tax rates.

Table 1 shows the emission factors of pollutants during the combustion of different fuels without the use of technologies to reduce emissions of pollutants.

Table 2 shows the tax rates for air emissions of certain pollutants by stationary sources of pollution, which include boilers of heating boilers, according to Articles 243.1 and 243.4 of the Tax Code of Ukraine [6].

In November 2019, 3 bills (draft laws) on increasing environmental tax rates were submitted to the Verkhovna Rada. The bill on Amendments to the Tax Code of Ukraine to increase environmental tax rates and implement European principles of modernization of Ukrainian industry 2367-1 of November 18, 2019, proposes to increase tax rates for air emissions from 2030. According to this bill the growth rate will be gradual: from 01 January 2021 to December 31, 2022, inclusive, tax rates are 75% of the rates provided by the bill, in 2023-2024 - 80%, in 2025-2026 - 85%, in 2027-2029 - 90%.

Bill 2367 of November 1, 2019 proposes to increase tax rates by 4 times (Table 2).

In EU countries, tax rates differ dozens of times, in Poland some of the lowest in the EU, in Sweden - the highest (Table 3), the rate - 34.64 UAH/EUR.

Sweden levies the highest carbon tax rate at €112.08 (US$ 132.17) per ton of carbon emissions, followed by Switzerland (€83.17, $98.08) and Finland (€62.00, $73.11). You'll find the lowest carbon tax rates in Poland (€0.07, $0.08), Ukraine (€0.33, $0.39), and Estonia (€2.00, $2.36).

Table 1. Specific pollutant emissions from fuel combustion

Fuel	Specific pollutant emissions, kg/t fuel				Fuel pollutant emission index, g/GJ			
	NO_x	SO_x	CO_2	PM_{10}	NO_x	SO_x	CO_2	PM_{10}
natural gas	2.127 [*]	0 [*]	1943.4 [*]	0.00 [*]	64.31 [28]	0 [28]	58748 [28]	0 [*]
coal	2.065 [*]	51.30 [*]	1918.9 [*]	47.20 [*]	100.9 [28]	2506 [28]	93740 [28]	2305.9 [*]
fuel oil	2.494 [*]	19.40 [*]	2973.0 [*]	15.74 [*]	64.311 [28]	500.26 [28]	76662,63 [28]	405,81 [28]
wood chips	0.928 [*]	0.112 [*]	1020 [*]	0.903 [*]	91 [25]	11 [25]	100000 [26]	88.5 [25]
wood pellet	1.36 [*]	0.187 [*]	1700 [*]	0.51 [*]	80 [25]	11 [25]	100000 [26]	30 [25]
sunflower husk pellets	1.36 [27]	3.2 [27]	1816.1 [27]	0.091 [*]	75.56 [*]	207.4 [27]	100893 [27]	5.911 [*]
straw briquettes	1.38 [27]	2 [27]	1544.2 [27]	0.171 [*]	89.03 [*]	127.4 [27]	99624 [27]	10.892 [*]
firewood	1.228 [*]	0.149 [*]	1512 [*]	1.195 [*]	91 [25]	11 [25]	112000 [*]	88.5 [25]
peat briquettes	2.76 [*]	2 [*]	1860.3 [*]	0.51 [*]	178.1 [*]	127.4 [*]	106000 [*]	30 [*]

* calculated by the authors on the basis of data [24, 25, 26, 27, 28, 29]

Table 2. Actual and project tax rates for air emissions of some pollutants, UAH/t

Pollutant	Existing tax rates	Bill 2367-1 of November 18, 2019					Bill 2367 of November 1, 2019
		2021-2022	2023-2024	2025-2026	2027-2029	2030	
NO_2	2451.84	2758.32	2942.21	3126.10	3309.98	3677.76	9807.36
N_2O	2451.84	2758.32	2942.21	3126.10	3309.98	3677.76	9807.36
CH_4	138.57	155.895	166.29	176.681	187.07	207.86	554.28
PM_{10}	92.37	103.92	110.85	117.776	124.70	138.56	369.48
SO_2	2451.84	2758.32	2942.21	3126.10	3309.98	3677.76	9807.36

Table 3. Tax rates for air emissions of certain pollutants in Ukraine, Poland and Sweden

Pollutant	Ukraine	Poland	Sweden	Poland	Sweden
	UAH/t			EUR/t	
NO_x	2451.84	4387.8	18359.2	126.67	530
CO_2	10.00	2.4	3882.5	0.07	112.08
SO_2	2451.84	4387.8	10392	126.67	300

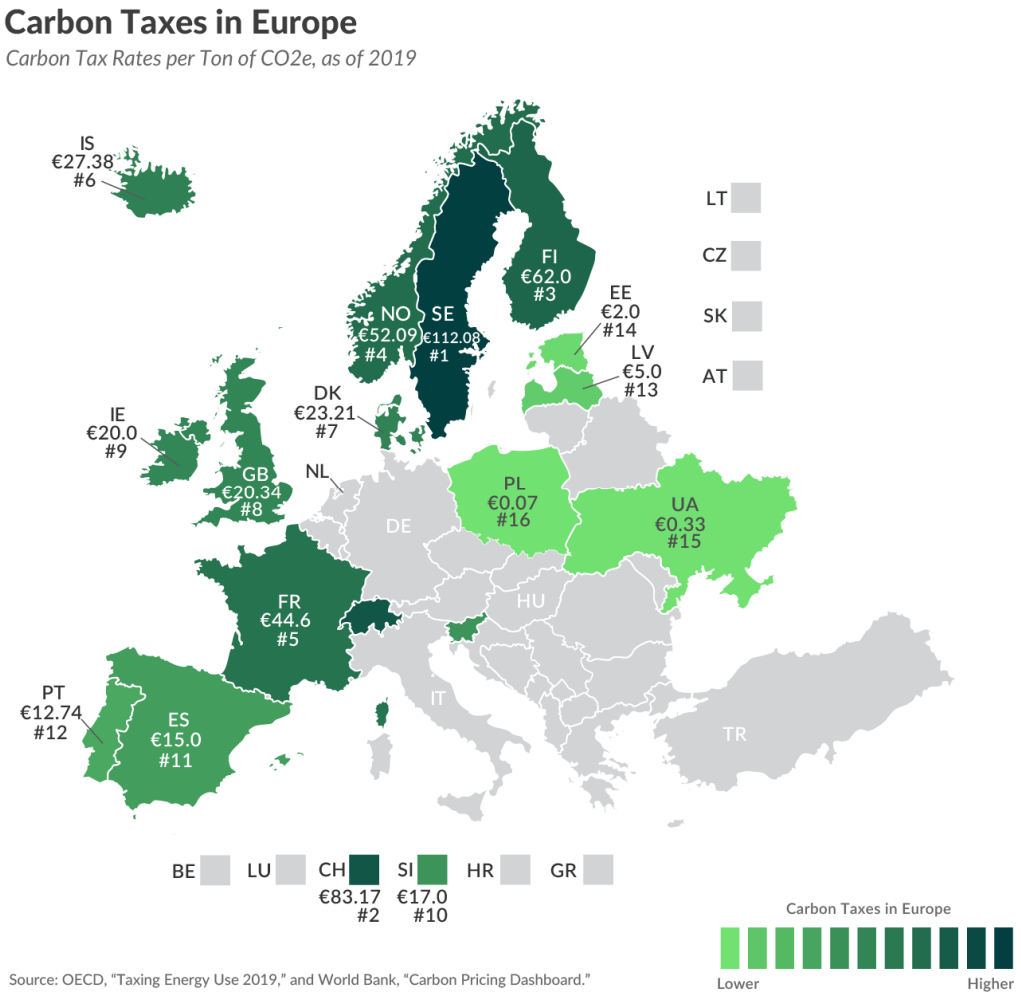

Fig. 2. Carbon Taxes in Europe [30].

It is proposed to calculate the levelized cost of heat taking into account the environmental tax, by the expression:

$$LCOH_{T_{eco}} = \frac{\sum_{t=1}^{N} \frac{I_t + M_t + F_t + T_t^{eco}}{(1+r)^t}}{\sum_{t=1}^{N} \frac{H_t}{(1+r)^t}} \quad (1)$$

where:
I_t is investment expenditures in year t
M_t is operations and maintenance expenditures in year t
F_t is fuel expenditures in year t
H_t is energy (heat) generation in year t
r is discount rate
N is lifetime of the technology
T_t^{eco} is environmental tax.

Thus, the change in LCOH due to the environmental tax is determined by the expression:

$$\Delta LCOH_{eco\ tax} = LCOH_{T_{eco}} - LCOH \quad (2)$$

Taxation of pollutant emissions in Ukraine is carried out in accordance with Section VIII of the Tax Code of Ukraine [6].

The expenditures included in the formula for determining the levelized cost of heat are divided into permanent (administrative) and variable (operational) costs.

4 Results and discussion

For the study, the authors used data from [9, 31], which was calculated the LCOH and the contribution of environmental tax in LCOH for three types of boilers with a capacity of 4.65 to 58 MW, burning natural gas, coal and fuel oil, which the most common for boiler houses of Ukraine [9], and for boilers on different types of biofuels with a capacity of 1 MW [31].

$\boldsymbol{\Delta LCOH_{eco\ tax}}$ is calculated to an increase in eco tax rates by 50% and 4 times (according to Ukrainian bills) and the eco tax rates in Poland (one of the lowest in the EU) and Sweden (highest in the EU).

The contribution of the environmental tax to the LCOH indicator depending on the different rates of the environmental tax, which were given in tables 2 and 3, are presented in the table. 4

Table 4. $\boldsymbol{\Delta LCOH_{eco\ tax}}$ at eco tax rates of Ukraine (current and project), Poland and Sweden for boilers on different fuels

Boiler, its power	Fuel type	LCOH without eco tax	$\Delta LCOH_{eco\ tax}$					
			Ukraine	Ukraine, Bill 2367-1 of November 18, 2019		Ukraine, Bill 2367 of November 1, 2019	Poland	Sweden
				from 2021	from 2030			
KV-GM-4-150, 4.65 MW	natural gas	1047.34	3.33	3.42	3.68	13.34	1.84	994.61
	fuel oil	1278.33	9.93	10.72	13.11	39.72	17.18	1359.99
KV-TS-4, 4.65 MW	thermal coal	705.27	36.75	40.68	52.48	146.98	87.38	1865.55
KV-GM -50-150, 58.2 MW	natural gas	1027.65	3.38	3.47	3.73	13.54	1.87	1009.66
	fuel oil	1241.06	9.85	10.64	13.01	39.41	17.05	1349.54
KV-TS -20, 23.2 MW	thermal coal	708.42	37.31	41.30	53.28	149.24	88.72	1894.23
KV-2.0, 2 MW	natural gas	1090.08	3.40	3.49	3.75	13.61	1.88	1015.15
ARS 1000, 1 MW	anthracite	720.45	38.61	42.80	55.40	154.42	93.49	2090.03
	wood	529.64	7.30	7.48	7.99	29.22	5.17	2313.97
	wood chips	687.35	6.59	6.75	7.26	26.34	4.95	2041.22
	natural gas	1125.28	3.79	3.90	4.20	15.18	2.16	1167.51
ARS 1000 BM, 0.98 MW	wood pellets	634.14	5.58	5.71	6.09	22.32	3.32	1774.06
	wood	492.70	6.71	6.87	7.34	26.84	4.75	2125.62
Gefest Profi-P 1000, 1 MW	straw briquettes	521.04	7.03	7.34	8.25	28.12	5.63	1793.16
	wood pellets	637.96	5.58	5.71	6.09	22.32	3.32	1774.06
	sunflower husk pellets	379.18	7.75	8.15	9.33	31.00	6.84	1798.75

In case of eco tax rates increasing for emissions of all pollutants in 4 times, the mentioned component of the LCOH will increase for natural gas boilers - from 3.40 to 13.34 UAH/Gcal, for fuel oil boilers will increase from 10 to 40 UAH/Gcal, for coal-fired boilers - from almost 40 to 150 UAH/Gcal.

For biofuel boilers the growth will be from 6-7 to 22-28 UAH/Gcal, namely from 5.58 to 22.32 UAH/Gcal for wood pellets boilers, from 7.75 to 31.00 UAH/Gcal for sunflower husk pellets boilers.

At current eco tax rates $\boldsymbol{\Delta LCOH_{eco\ tax}}$ is from 0.3% for gas boilers to 5.3% LCOH, for biofuel boilers from 0.9% (wood pellets) to 2.0% (sunflower husk pellets). If the eco tax rates are increased in 4 times, it will be from 1.2% (gas boilers) to 21% LCOH (coal boilers).

Poland has the lowest environmental tax rates in EU, so the environmental component of LCOH (taxes), for their case will increase for fuel oil boilers by 70%; for coal-fired boilers it will more than double, and for natural gas boilers it will generally halve (due to a lower CO_2 tax rate).

If the highest rates in the EU (Sweden) are used, the environmental component LCOH (tax) for coal-fired boilers will be in 2.6 times larger as the investment, operating and fuel costs component, for gas boilers, the environmental component will be 95%, and for fuel oil boilers - 105%, for biofuel boilers – will be in 2.8-4.7 times larger. The largest contribution is the tax on CO_2 emissions, the tax rate of which is 388 times higher than in Ukraine. The environmental component LCOH (tax) under these conditions is tens of thousands of times higher than at existing tax rates in Ukraine.

With the introduction of Sweden tax rates, the cheapest will be heat from high-power gas boilers - 2040 UAH/Gcal, heat from boilers burning some types of biofuels (2728, 2843 UAH/Gcal) becomes more expensive even than heat from fuel oil and coal boilers (2570-2638 UAH/Gcal). This will stimulate further introduction and use of gas boilers, which contradicts the goal of increasing the share of local biofuels.

In many countries around the world, including EU countries, biofuels are considered CO_2 neutral and no CO_2 tax is levied. Subject to the introduction of Swedish tax-free rates for CO_2 emissions, the environmental component of LCOH (taxes) for biofuel boilers will range from 7.2 to 16.1 UAH/Gcal.

5 Conclusions

In December 2019, the European Commission officially presented The European Green Deal, a new EU economic development program aimed at achieving climate neutrality on the European continent by 2050. Many previous global, European, and national programs also aim to reduce emissions of pollutants into the atmosphere. In this context, one of the directions is the development of alternative energy sources (in particular the wider use of biofuel boilers) on the one hand and increasing environmental tax rates on the other (which will lead to reduced emissions).

Many leading countries in the world have long used changes in environmental tax rates as one of the tools to achieve sustainable development goals. Ukraine is also trying to join them. As of December 2020, there are 3 different bills in the Parliament of Ukraine, the adoption of which will change the rates of environmental tax in Ukraine, sometimes in times. However, as of December 30, 2020, none of these bills have been adopted.

It is established that at the current environmental tax rates in Ukraine there are almost no economic incentives for the introduction of technologies to reduce the concentration of pollutants in emissions, but increasing environmental tax rates may change this situation, and environmental tax rates will be an effective tool for achieving sustainable development goals in Ukraine.

The authors calculated the environmental component of LCOH (taxes) at eco-tax rates of Ukraine (current and project), Poland, and Sweden for boilers on different fuels. If the highest rates in the EU (Sweden) are used, the environmental component LCOH (tax) for all fuel type boilers will be equal to the investment, operating and fuel costs component for natural gas and fuel oil boilers, in 2.6-4.7 times larger for coal and biofuel boilers. The cheapest will be heat from high-power gas boilers - 2040 UAH/Gcal, heat from boilers burning some types of biofuels (2728, 2843 UAH/Gcal) becomes more expensive even than heat from fuel oil and coal boilers (2570-2638 UAH/Gcal). This will stimulate further introduction and use of gas boilers, which contradicts the goal of increasing the share of local biofuels.

Only increasing the rates of the eco-tax without its smart administration (for example, benefits, refund of part of the funds for the eco-modernization, etc.) will not ensure the effective use of these tools to achieve sustainable development goals.

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